MSG

TITLE : Interface Control Document
MSG Data Handling System

DOC. REF. : MSG-BE-IC-0001

BE REF. NR. : 436

DRD NR. : N/A

REV. : H

DATE : 31-07-2000

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REVISION LOG

REV	DATE	DESCRIPTION	AUTHOR
0	06.10.1997	Original (Replaces 436.TN.033)	P. Bijl
A	13.03.1998	Update after review of DASA and comments per fax MSG-RIBRE-TX-389 Complete Rewrite after Internal Documentation Meeting with DASA	K. Bakker P. Bijl
B	27.10.1998	Update after meeting with DASA/ESA about ICD contents and layout NASA comments post CDR included (ISS-MDM Command layout) Updated to : RID: MSG-CDR-DHS-101, 121 and 134	P. Bijl
C	03.05.1999	Update after review by Origin	E. Schreutelkamp
D	16.08.1999	Update after review by DASA and B.E.	E. Schreutelkamp
E		Not officially released	
F draft1	19.04.2000	Version changed from Ground Unit specific to Engineering and Flight Unit Specific. Video interface added, several message formats updated, various adaptations. Adaptations for word alignment added, uniform log messages/command acks. ASL commands added. MLC commands added. Overview of all commands collected in Appendix E. Internal review by Bradford/Origin pending.	E. Leussink, R. Trompert
	25.05.2000	Updated with comments from DASA	E. Leussink
F draft2	26.05.2000	Updated with comments after internal Origin review. Furthermore: Grouped safety data in one section (§3.3) Grouped log messages and command acknowledges (§3.1.16) Details on file transfer to and from WV added	E.Leussink/R. Trompert

REV	DATE	DESCRIPTION	AUTHOR
	04.07.2000	Changed messages and app. B to be compatible with SSL private header definitions. Updated with comments from ESA and NASA Removed ASL, integrated functionality into ASW Moved log messages from telemetry to housekeeping. Updated MLC interface (including file transfer). Grouped and restructured file transfer in general. Added RAM drive and additional telemetry commands. Completed safety data and RPDA issues.	E. Leussink
F	07.07.2000	updated after review by Origin and Bradford	E. Leussink
G	18.07.2000	updated with comments from Astrium, ESA and NASA	E. Leussink
H	31.07.2000	Redefined MLC protocol	E. Leussink

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1. Introduction

This document presents the Software Interface Control Document for the MSG Data Handling System.
Previous versions of this document up to revision F were targeted at describing the Ground Unit (GU) of the Microgravity Science Glovebox (MSG) system. Due to the change in hardware from AVECS based to SPLC based, and with it the changes in software, the addition of a video interface and several other adaptations, revision F is dedicated to describing the Engineering and Flight Units.

1.1 Purpose

The purpose of this document is to define the external interfaces between the ASW of the MSG Rack controller and its external interfaces. This information is intended for the developers of experiment software, CMP embedded S/W (ESW), MSG Laptop Computer and ISS/MDM.

1.2 Scope

The scope of this document covers the S/W interfaces (data frames, command structures and settings, where applicable) of the Application Software (ASW) of the MSG Data Handling System. The ASW interfaces with the CMP, Work Volume, RPDA/AAA, MLC, Video system and ISS/MDM. The ASW also interfaces with the Basic Software (BSW), but the BSW itself is outside the scope of this document and we refer to [AD8].
The definitions given apply to the MSG Engineering and Flight Units, which are identical within the scope of this document. For the details regarding the Ground Unit we refer to revision D, or it's updated version, of this document.

1.3 Definitions, Acronyms and Abbreviations

We refer to [AD2].

Additionally:
BSW - Basic Software
BCD - Binary Coded Decimal
CMP - Command and Monitoring Panel
DHS - Data Handling System
ESEM - Exchangeable Standard Electronic Module
ESW - Embedded Software (of CMP)
LRT - Low rate Telemetry
LSB - Least Significant Bit
MLC - MSG Laptop Computer. Laptop connected to the internal MIL-bus of the MSG, previously designated **PCS**.
MRDL - Medium Rate Data Link
MSB - Most Significant Bit
PL - payload
SA - Sub Address (MIL-bus)
SSL - SPLC Service Layer, part of the BSW
VCU - Video Control Unit
VD - Video Drawer

1.4 Notations

1.4.1 Notations

The following notations are used in this document.

Binary Notation	<value>B or <value>b	e.g. 1010B or 1010b
Hexadecimal Notation	0x<value>	e.g. 0xAB1F
Decimal Notation	<value>	e.g. 20
Binary Coded Decimal	BCD<value>	see §1.4.4

The following nomenclature is used to describe contiguous groups of bits within a data packet:

1 bit	=	1b				
1 byte	=	1B	=	8 bits	=	1 octet
1 word	=	2 bytes				
1 double word	=	4 bytes				
1 kilobit	=	1Kb	=	1024 bits		
1 kilobyte	=	1KB	=	1024 bytes		
1 megabit	=	1Mb	=	1024 Kb		
1 megabyte	=	1MB	=	1024 KB		

1.4.2 Nomenclature

short	=	16 bits, range: –32768 … +32767
integer	=	32 bits, range: –2147483648 … +2147483647
unsigned short	=	16 bits, range: 0 … 65535
unsigned integer	=	32 bits, range: 0 … 4294967295
float	=	32 bits, ANSI/IEEE 754

1.4.3 Byte and Bit order

Data is stored, transmitted and received in Big Endian format by the MSG DHS [RD11].

The following convention is used to identify each bit in an N-bit field.

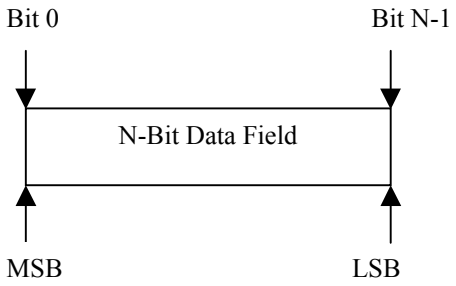

Figure 1: general bit naming convention

1.4.4 Binary Coded Decimal

Timestamps are in some cases transferred in binary coded decimal (BCD) notation. In this notation, the upper and lower 4 bits in a byte each are used to represent a number between 0 and 9. This makes the raw data more readable when the values of the upper and lower 4 bits in each byte are displayed as separate values.

1.5 References

1.5.1 Applicable Documents

[AD1] ESA, ESA-PSS-05-0, issue 2, February 1991, ESA Software Engineering Standards.
[AD2] Daimler-Benz Aerospace, MSG-RIBRE-LI-0002, 18.11.96, Issue 6, “Directory of acronyms and abbreviations”.
[AD3] Daimler-Benz Aerospace, MSG-RIBRE-SPE-001, 26.02.1999, Issue 3, Rev. E, “MSG System Specification”.
[AD4] Daimler-Benz Aerospace, MSG-RIBRE –RQ-002, 10.11.1997, Issue 2, Rev. 1, “MSG DHS Software User Requirements Document”
[AD5] NASA, SSP-52050, Rev. A, 25.09.1998, "Software Interface Control Document Part 1, International Standard Payload Rack to International Space Station".
[AD6] NASA, SSP-57002, Rev. 0, 10.07.1998, "Payload Software Interface Control Document Template".
[AD7] NASA, SSP-41175-2, Rev. 0, "Software Interface Control Document Part 1, Station Management and Control to International Space Station Book 2, General Software Interface Requirements".
[AD8] DaimlerChrysler Aerospace, SPO-PC-RIBRE-ICD-0006, 15.09.1999, Issue 1, Rev. C, “Software Interface Control Document, SPLC Basic Software to Application Software”
[AD9] MIL-STD-1553B, 21 September 1978, “Department of defense interface standard for digital time division command/reponse multiplex data bus”
[AD10] Bradford Engineering, MSG-BE-RQ-0001 02.10.1997, Rev. E, “MSG Application Software Requirement Document”, future replacement by new document pending
[AD11] Carlo Gavazzi Space, SPO-PD-CGS-UM-0001, March 2000, Issue 1, “SPOE – RPDA User Manual”.

1.5.2 Reference Documents

[RD1] Bradford Engineering, MSG-BE-DD-0003, Rev. 0, 23.10.1997, "MSG CMP Embedded Software Detailed Design Document".
[RD2] Bradford Engineering, MSG-BE-AD-0001, Rev. B, 06.08.1997, "MSG CMP Embedded Software Architectural Design Document".
[RD3] Bradford Engineering, MSG-BE-DD-0001, Rev. C, 23.10.1997, "MSG Rack Controller Application Software Detailed Design Document".
[RD4] Astrium, MSG-RIBRE-TN-0xxx, RPDA Measurement and Calibration list, document release pending
[RD5] Daimler-Benz Aerospace, MSG-RIBRE-RQ-002, 10.11.1997, Issue 1, Rev. 2, “MSG DHS User Requirements Document”.
[RD6] Daimler-Benz Aerospace, MSG-RIBRE-RP-002, 25.02.1999, Issue 7, Rev. B, “Design Definition Document”
[RD7] Bradford Engineering, VID-BE-ICD-0001, Rev. C, 17-07-1998, "Interface Control Document Video System".
[RD8] ILC Data Device Corporation, Fifth Edition, 1995, "MIL-STD-1553 Designer's Guide".
[RD9] ESA, ESA PSS-04-107, Issue 2, April 1992, "Packet Telecommand Standard".
[RD10] Bradford Engineering, MSG-BE-MA-0003, Rev. 0, 01.10.1999, “Software User manual MSG ASW”
[RD11] Daimler-Chrysler Aerospace, SPO-PC-RIBRE-SPE-0001, 02.09.1999, Standard Payload Computer Specification”

1.6 Overview

This document gives settings and definitions of communications over all interfaces within the MSG-DHS. This covers all interfaces between the Rack Controller (RC) and the CMP, the video system, the RPDA/AAA, the MLC, ISS/MDM and the test connector.

2. SYSTEM OVERVIEW

2.1 System Architecture

The MSG Data Handling System contains a Rack Controller (RC) which is a so-called Standard Payload Computer (SPLC) running VxWorks as operating system and the software that it runs.
This software comprises basically of two layers, the Basic Software (BSW) and the Application Software (ASW).

Figure 2 depicts the overall DHS for MSG and locates the ASW and BSW as a component of the RC software. The ASW and BSW operate together, fulfilling the primary data handling functions required by MSG. The BSW provides generic data management services that are applicable to payloads in the USlab and Columbus Lab environment in the International Space Station (ISS). It is a software layer that implements the low-level protocols of data transmission between the DHS and its internal and external interfaces. Internal interfaces are P/L-related interfaces not communicating with a system outside the SPLC. All interfaces with a H/W connection to the outside world of the SPLC are denoted as external interfaces. In addition, the BSW performs the monitoring of housekeeping variables for 'out of limit' situations. The ASW contains all MSG-specific software. The main tasks of the Application Software ASW are:

- Configuration of the data routing tables.
- The routing of data.
- Reception and forwarding of commands and execution of commands meant for the ASW.
- Event handling in case of 'out of limit' situations.
- Housekeeping data handling (e.g. data is supplied by the ASW to the BSW for monitoring and the ASW formats and distributes the housekeeping data).
- Generation of payload specific log messages regarding operating status, critical events, error conditions etc.
- Error messages handling.
- Data file transfer.
- Experiment data handling
- Providing time stamps.

In general, all data arriving on interfaces of the RC is identified by the ASW and then routed to its destination within the ASW for further processing. Routing a block of data takes place by acquiring messages sent to the Rack Controller from the BSW hardware interfaces, subsequent identifying the final destination(s) of a message and then transmitting this data to the destination(s), again using the BSW hardware interfaces. But the ASW also performs internal functions, when necessary. This could be for instance supplying a housekeeping parameter to the BSW for monitoring or log a particular event.

The ASW will handle all dialogs with the Command and Monitoring Panel (CMP) including reception of CMP Sensor Board (SB) generated housekeeping messages.

The ASW is responsible for handling discrete and analogue data generated by an experiment located in the work volume. Referring to Figure 2, data will be acquired by the Experiment Control Board (ECB) of the CMP, formatted and then transmitted to the RC via interface number 2. From there the data will be processed and routed by the ASW. Messages from the MLC, internal MIL-bus, experiment interface (WV1 and WV2), the video interface and the external MIL-bus will be handled by the ASW in a similar way.

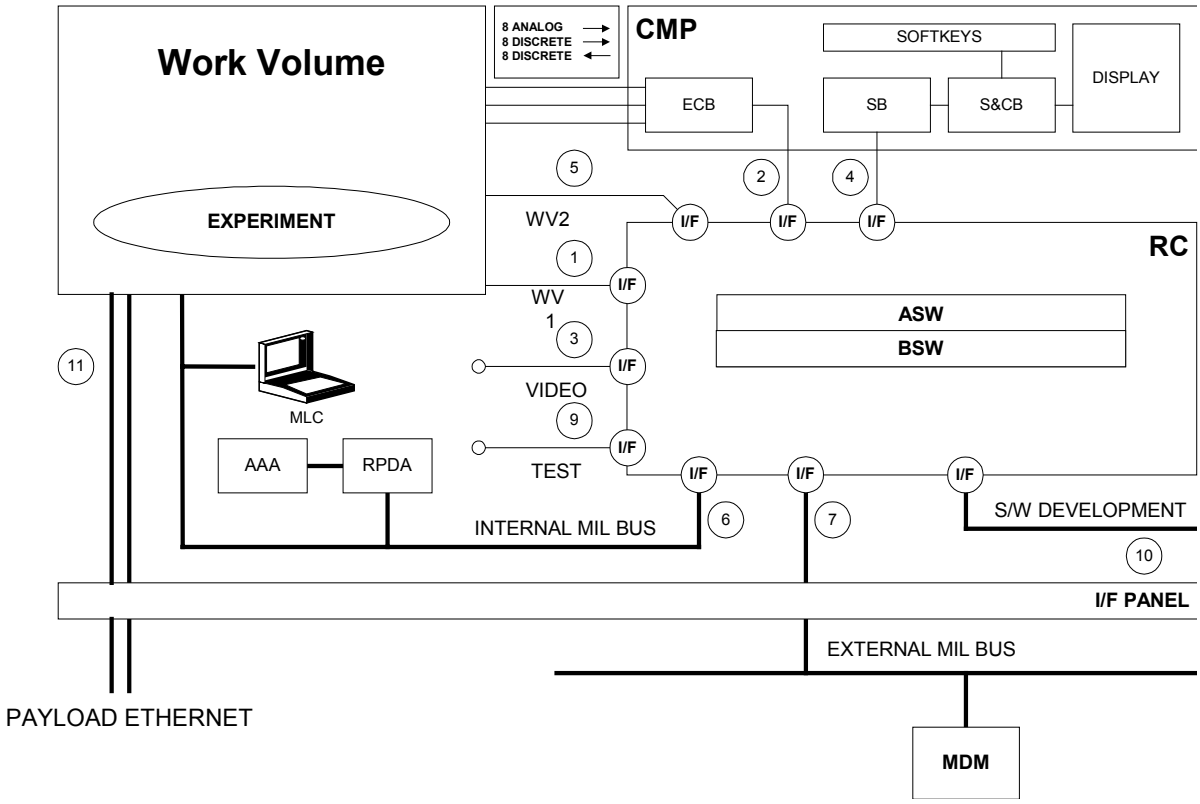

Figure 2: Overview MSG Data Handling System Interfaces. The interfaces are numbered according to the numbering scheme in [RD5]. See [RD6] for connector numbers.

The MSG Data Handling System uses three types of interfaces: RS422 standard, MIL-STD-1553B and Ethernet. Two RS422 interfaces are used internally to connect the MSG-RC to the CMP for transmission of data to and from the RC (e.g. experiment data, housekeeping data, experiment related commands, ECB and SB commands and RPDA/AAA and MSG-DHS status information).

The MIL-STD-1553B bus is used to connect MSG components, i.e. the RPDA/AAA and the MLC to the RC. Another MIL-STD-1553B bus is used to connect the RC to the ISS/MDM. The Ethernet is used for software development purposes. One of the RS422 interfaces, indicated as the test interface, gives direct access to the operating system of the RC and is also used for software development.

2.2 Interface Description

The following table presents a short overview of interfaces as displayed in Figure 2 and lists the applicable sections.

Int.nr	Ident	Type	Use for interfacing to:	Section/page
1	WV 1	RS422	Primary Direct Experiment Connection to RC from within the Work Volume	§3.1.5, p. 19
2	ECB	RS422	Experiment data packet / Experiment related commands	§3.1.6, p. 21
3	VCU	RS422	Video commanding	§3.1.8, p.28
4	CMP	RS422	Housekeeping data packet / Core Facility commands	§3.1.9, p.30
5	WV 2	RS422	Secondary Direct Experiment Connection to RC from within the Work Volume	§3.1.6, p.21
6	Internal	MIL1553	RPDA / AAA and MLC on internal MIL-bus	§3.1.10, p.33 and §3.1.11, p.41
7	External	MIL1553	ISS MDM on external MIL-bus	§3.1.12, p. 49
9	test	RS422	Test serial connector	§3.1.13, p. 60
10	S/W dev	Ethernet	IEEE 802.3 Ethernet for S/W development	§3.1.14, p.60
11	PL Ethernet	Ethernet	D IEEE 802.3 Ethernet feed through connection in WV	§3.1.15, p.60

Table 1: Interface description of MSG. The interface numbers are used throughout this document.

The settings of the serial interfaces are fixed (see the appropriate sections). We refer to the Design Definition Document [RD6] for the relation between logical interface and physical connector number.

2.3 Word alignment

In order to simplify data handling by the MDM, all data packets, which are sent or received over the external MIL-bus to the ISS will be word aligned. All data elements should start at an even offset in the data packet, unless the data element is a byte and is preceded by another byte data element. All packets transferred over the external MIL-bus must contain an even number of bytes altogether.
Please take note of the fact that this does not imply that *every* element in *all* the messages need to be word aligned; if only a part of a message is received from or send to the ISS/ground, the rest of the message does not need to be word aligned.
It is the responsibility of the sender of a message to make sure it is word aligned, when it is intended to be transferred over the external MIL-bus.
As a result, in some packages extra bytes have been added, which are indicated as ‘Not Used’ and have a non-defined value.

3. Interface Definitions

In the following Chapter the separate interfaces as presented schematically in the previous chapter are described.

3.1 External Interface Description (Block Definitions) & MSG headers

This section describes the definitions of all interfaces that have a hardwired connection to the SPLC. This therefore also includes the interfaces between the ASW and the CMP (i.e. ECB and SB). Part of the protocol used on all these interfaces is the packet definition. For successful routing of data, header information is added to the data frame. All data traffic on internal and external interfaces uses standard headers that contain the following information, unless hardware constraints or external protocol definitions dictate otherwise.

Header Element	size (bytes)	Description
Source	1	From which interface
Destination	1	To which interface
Class	1	Classification of data
Type	1	Type of data
Length	2	Length of data (number of bytes following this field). This field is not present in the command messages described in §3.1.12.2.6 (page 55)

Table 2: Message header elements

Data sources sending data to the RC must add this header to their data frames as is shown in the message definitions throughout this document. The fields in the header are described in more detail below.

3.1.1 Source & Destination

The Source and Destination fields are vital for routing data from a source to a destination within the RC. The values are in the message definitions indicated by symbolic values. The corresponding enumeration is listed in Appendix B.

3.1.2 Class

The class field is an 8-bit field. Bit 0, the most significant bit (MSB), indicates whether the data frame contains a command (the bit is set to 1) or data (the bit is set to 0). The rest of the bit field is interpreted accordingly:

Class field bit definition of command message			
Bit offset	value	Bit name	remarks
0 (MSB)	1	cmd/data	indicates Command
1	0	Acknowledge flags	option not supported by ASW
2	0		option not supported by ASW
3	0		option not supported by ASW
4	1		accept/acknowledge reception of command
5		Sequence counter	Since the class field is returned in the command acknowledge, the sequence counter can be used by the original sender to link the acknowledge to the original command. It is not used by the ASW and is to be set by the sender of the command.
6			
7 (LSB)			

Table 3: Bit fields in the class field of the MSG header when message is a command

Class field bit definition of data message			
Bit offset	value	Bit name	remarks
0 (MSB)	0	cmd/data	indicates data
1		Type of class indicator	In this case the 7 bits following MSB is a numerical value in the range of 0 to 127. The possible values and clarifications are listed in Appendix B and are distinguished by the "mc_" prefix.
2			
3			
4			
5			
6			
7 (LSB)			

Table 4: Bit fields in the class field of the MSG header when message contains data.

3.1.3 Type

When the *class* field indicates that the data frame contains a command message, the Type field will contain the command ID.
If the *class* field indicates that the data frame contains data, the type field is a numerical value providing additional identification of the data (e.g. identifying it as telemetry).

3.1.4 Length

The length field indicates the number of bytes that follow after the length field. But this field is *not* present in the command messages described in §3.1.12.2.6 (page 55)

3.1.5 Work Volume Primary Direct Experiment Data Interface 1 (I/F 1)

The Primary Direct Experiment Interface (1) is a serial RS422 line connecting the Rack Controller to the MSG WV for direct connections of experiments.
Data across this interface can be one of the following:

Type	RS422 Electrical Industry Standard	
Settings	19200, 8N1 (fixed), see [RD6] for connector number	
Data	From RC to WV	From WV to RC
	Experiment Commands	Experiment Health and Status Data
	Time Of Day	Experiment Low Rate Telemetry
	file transfer	Log messages
		Command Acknowledges
		file transfer

Table 5: Data over WV interface

3.1.5.1 Experiment Low Rate Telemetry data

The WV can send raw experiment data to the ground via this message. No processing is performed by the DHS. Before LRT can be transmitted to ground, however, an LRT channel must be opened using the cmd_OPEN_LRT_CHANNEL as described in §3.1.12.2.5 (page 53).

Title : Direct Experiment Data Direction: WV1 -> RC Protocol: EDLF Frequency: 0 - 1 Hz				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_WV1_LRT	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_TELEMETRY	
3	Type	1	mat_UNSPECIFIED	
4	Length	2	Number of bytes following this field	Length * Frequency not to exceed 1000 Bytes/sec
6	TOD- Century	1	BCD20	BCD Notation
7	TOD- Year	1	BCD00.BCD99	
8	TOD- Month	1	BCD01.BCD12	
9	TOD- Day	1	BCD01.BCD31	
10	TOD- Hours	1	BCD00.BCD23	
11	TOD- Minutes	1	BCD00.BCD59	
12	TOD- Seconds	1	BCD00.BCD59	
13	Not Used	1		Word alignment
14	Data	0..1000		Must be an even number of bytes!

Table 6: WV telemetry data

Note that the data block is defined as *unstudied* data; refer to §3.5.1.1 on page 73 for a description of the EDLF protocol.
Do not combine LRT and file transfer from WV1 to the RC. The data rate will exceed the maximum hardware bandwidth, which results in loss of data. However, H&S data must always be sent.

3.1.5.2 Experiment Health and Status data

The WV sends the following predefined Health & Status data.

Title : Direct Experiment Health and Status Data Direction: WV1 -> RC Protocol: EDLF Frequency: 1 Hz					
Offset (bytes)	Field Name	Length (bytes)	Offset(bits)	Value	Remarks
0	Source	1		ma_WV1_HS	
1	Destination	1		ma_UNSPECIFIED	
2	Class	1		mc_HOUSEKEEPING	
3	Type	1		mat_HS	
4	Length	2		44	Number of bytes following this field
6	WV1_H&S_DiscreteFire WV1_H&S_Discrete1 WV1_H&S_Discrete2 WV1_H&S_Discrete3 WV1_H&S_Discrete4 WV1_H&S_Discrete5 WV1_H&S_Discrete6 WV1_H&S_Discrete7	1	0 MSB 1 2 3 4 5 6 7 LSB		8 bits, used as discrete data Discrete0 is interpreted as fire bit. See §3.1.5.7 on page 21 for details.
7	WV1_H&S_Discrete8 : WV1_H&S_Discrete15	1	0 : 7		
8	WV1_H&S_Discrete16 : WV1_H&S_Discrete23	1	0 : 7		
9	WV1_H&S_Discrete24 : WV1_H&S_Discrete31	1	0 : 7		
10	WV1_H&S_Ushort0	2			20 unsigned shorts
:	:				
48	WV1_H&S_Ushort19	2			

Table 7: WV1 Health & Status data

The ASW will detect the presence of an experiment by receiving the H&S messages. An experiment is therefore required to send H&S data once every second.
Note that the ASW can perform limit checking on these values. However it does not know what the values represent as this is experiment dependent information. Limit checking on a parameter should be enabled and limits should be set by using the appropriate commands (3.1.12.2.6, page 55) and it is the responsibility of the experiment to scale the values in the H&S packet to fit the data types listed in the table (e.g. when a float is sent in Ushort0, the experiment should scale the float to fit in a short and the limit checking should be adapted to fit the scaling). Upon transgression of a user-defined limit for one of the parameters, other than the fire bit, a log message will be generated. See §3.3 (page 66) for all MSG Safety Data related issues.

3.1.5.3 Experiment Commands

Title : WV1 commands Direction: RC->WV1 Protocol: EDLF Frequency: Asynchronous				
Offset (bytes)	Field Name	# bytes	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	
1	Destination	1	ma_WV1	
2	Class	1	mc_CMD_AND_ACK +sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: 0x00..0xFF	Experiment specific
4	Length	2	Parameter Length	length of parameters
6	Parameters	0..100		Optional parameter(s) **Must be an even number of bytes!**

Table 8: Direct Experiment commands

3.1.5.4 File Transfer, WV to RC

Experiments in the work volume may send files to ground or the MLC through the RS422 WV interface.
See §3.4 on page 70 for a description and details regarding file transfers in the MSG DHS.
Do not combine LRT and file transfer from WV1 to the RC. The data rate will exceed the maximum hardware bandwidth, which results in loss of data. But H&S data must always be sent.

3.1.5.5 Command acknowledges and Log messages

Log messages are formatted according to the definition described in Table 48 (page 61).
Command Acknowledges are formatted according to the definition described in Table 50 (page 62), with the source field set to *ma_WV1_LOG.*

3.1.5.6 TOD data

The WV receives Time Of Day data. The format and details will be as specified in section 3.2.1 (page 63). The transmission of TOD to the WV interface can be stopped and started using the appropriate delete and add route commands described in §3.1.12.2.5 (page 53).

3.1.5.7 Safety data

The Health and Status Data from WV interface can be monitored by the ASW and could result in predefined actions when a limit is transgressed. By default, WV1_HS_Discrete0 in the H&S packet is interpreted as the fire detection bit and is monitored by the Rack Controller. When this bit is set, predefined actions will be taken by the ASW and a log message will be generated.
Refer to §3.3 (MSG DHS Safety data, page 66) for a description of all MSG safety data related issues.

3.1.6 Work Volume Secondary Direct Experiment Data Interface 2 (I/F 5)

This interface is in functionality identical to Direct Experiment Data Interface 1 (WV1). Data formats are identical except for the source and destination fields in the MSG header. In all source or destination acronyms the letter combination ‘WV1’ is replaced by ‘WV2’ and in the Health & Status data (Table 7, page 20: all WV1 prefixes are replaced by WV2). See [RD6] for connector numbers.

3.1.7 Experiment control Board Interface (I/F 2)

The Experiment Control Board Interface is a serial RS422 line connecting the CMP Experiment Controller Board (ECB) to the Rack Controller and services experiments connected to the experiment connector inside the MSG WV.

Data across this interface can be one of the following:

Type	RS422 Electrical Industry Standard	
Settings	38400, 8N1 (fixed) , see [RD6] for connector number	
Data	From RC to CMP (see Table 12)	From CMP to RC
	Experiment Commands (discrete)	Experiment Telemetry Data Packet - 0 to 8 analogue channels - 0 or 8 digital channels
	Data Flow Control Commands	Log Messages
		Command Acknowledges

Table 9: Communications overview of ECB interface

3.1.7.1 Experiment Telemetry data

The Experiment telemetry data contains the (12 bits) digitized values of 0 *to* 8 analogue channels and 0 *or* 8 digital 1-bit signals from the WV. To guarantee the minimum required sampling rate (1500 Hz when 1 channel is sampled, 750 Hz each channel when 2 channels are sampled, 500 Hz for 3 channels etc.) over the serial interface a simple protocol is used to minimize overhead. The data flow between ECB and RC is reformatted by the ASW before the telemetry data is re-sent to it's final destination according to the definition in Table 47 (page 58).
Before LRT can be transmitted to ground, however, an LRT channel must be opened using the command cmd_OPEN_LRT_CHANNEL as described in §3.1.12.2.5 (page 53).

Data is transmitted in fixed length blocks preceded with a SYNC word and terminated with a checksum. Note that due to H/W limitations the sampling rate may not exceed the maximum of 1500 Hz.

Title : Experiment telemetry data Direction: ECB->RC Protocol: Raw (data is sent as described in this table; no additional EDLF protocol) Frequency: 0.125Hz … 3.03 Hz				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	SYNC	2	0x55AA	Sync word
2	Length	2	0x03F6	Length of the remainder of the message (unsigned 16 bit)
4	Source	1	ma_ECB_LRT	
5	Destination	1	ma_UNSPECIFIED	Determined by routing table
6	Class	1	mc_TELEMETRY	
7	Type	1	mat_UNSPECIFIED	
8	Sequence counter	2	0..0xFFFF	Increased by each new message
10	ESW Timestamp	2	0x0000..0xFFFF	Unsigned 16 bit milliseconds counter. ASW adjusts to proper value
12	Included Analogue channels	1	Bit pattern MSBit (0) = chan 8 LSBit (7) = chan 1 (0 = incl., 1=excl.)	Number of channels sampled data
13	Included Digital channels	1	0x00 = no dig. Chan. 0xFF= all 8 dig. Chan.	Number of digital channels in sampled data, 0 or 8
14	Frequency	1	0x01..0xFF	
15	Not used	1	0	Word alignment
16	DATA	1000		See Figure 3
1016	Checksum	2	0x0000 ..0xFFFF	16-bit addition without carry over all bytes (excluding checksum).

Table 10: ECB low rate telemetry

Data field organization as a function of selected channels				
Number of analogue channels.	Number of digital channels	Number of bytes per frame	Number of frames in data	Length of valid data
0	0	0	0	0
1	0	2	500	1000
1	8	4	250	1000
2	0	4	250	1000
2	8	6	166	996
3	0	6	166	996
3	8	8	125	1000
4	0	8	125	1000
4	8	10	100	1000
5	0	10	100	1000
5	8	12	83	996
6	0	12	83	996
6	8	14	71	994
7	0	14	71	994
7	8	16	62	992
8	0	16	62	992
8	8	18	55	990

SAMPLED DATA FORMAT 'Digital channels' = '11111111' B 'Analogue channels' = '01001010'B				
Offset (bytes)	Contents	Length (bytes)	Remarks	
0	Dig. Chan 1-8	2	LSBit (7) = chan 1 MSBit (0) = chan 8	Frame 1
2	Ana. chan 2	2	12 bit value in 12 MSBits	
4	Ana. chan 4	2		
6	Ana. chan 7	2		
8	Dig. Chan 1-8	2	2nd value for dig. Channels	Frame 2
10	Ana. chan 2	2	2nd value for ana. chan 2	
12	Ana. chan 4	2		
14	Ana. chan 7	2		
….	….	….	….	
…	….	….	….	
996	Ana. chan 4	2		
998	Ana. Chan7	6	last data	

SAMPLED DATA FORMAT 'Digital channels' = '00000000' B 'Analogue channels' = '10011011'B			
Offset (bytes)	Contents	Length (bytes)	Remarks
0	Ana. chan 1	2	
2	Ana. chan 2	2	
4	Ana. chan 4	2	
6	Ana. chan 5	2	
8	Ana. chan 8	2	
….	….	….	….
…	….	….	….
998	Ana. chan 8	2	last data

Figure 3: Data field organization as a function of selected channels

When an erroneous checksum or a missing SYNC is detected the data will be discarded and an error message will be generated.

3.1.7.2 ECB Configuration and Control commands

The following commands control the data flow and contents of the ECB Telemetry data that is sent from the Experiment Data 1 & 2 connectors in the WV.

Title : ECB command messages Direction: RC->ECB Protocol: EDLF Frequency: Asynchronous				
Offset (bytes)	Field Name	# bytes	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	
1	Destination	1	ma_ECB	
2	Class	1	mc_CMD_AND_ACK +sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: See Table 12	Command specification
4	Length	2	See Table 12	
6	Parameters	see Table 12	See Table 12	Optional parameter(s)

Table 11: ECB command messages.

CMD ID (see app. B for values)	description	Parameter (1 byte each)		Length (Param bytes)	Remarks
		name	offset		
cmd_ENABLE_ECB_DATA	Start sending LRT	<No parameters>		0	
cmd_DISABLE_ECB_DATA	stop sending LRT	<No parameters>		0	
cmd_OUTPUT_BYTE	bitmask to turn on/off the 8 digital outputs	Output byte	6	2	LSBit (0) = dig. output 1 MSBit (7) = dig. output 8 0 = off; 1=on
		<Not Used>	7		Word alignment
cmd_SELECT_CHAN	configure what LRT to send	Analogue channels	6	4	LSBit (0) = chan 1 MSBit (7) = chan 8 0 = off; 1=on
		Digital channels	7		All 8 digital channels are switched on/off together 0 = OFF; 1 = ON
		Freq. (Hz)	8		Frequency will be 1500/this number (0x01…0xFF)
		<Not Used>	9		Word alignment

Table 12: ECB Configuration and control command codes

Notes:

- Specifying 0 analogue channels and 0 digital channels will generate a parameter error. To stop LRT, the corresponding stop command should be send instead of sampling zero channels.
- The last correctly received configuration command will determine the settings of the LRT data.
- By default, all 8 eight analogue channels will be sampled, when LRT is started for the first time since startup without initialization.
- Start and Config commands are only allowed when LRT is not running. When they are sent anyway, an 'invalid command' message will be generated by the ECB and the command will be discarded.
- When a Stop command is received by the ECB while LRT is not running no action is taken by the ECB and there will not be a log message.
- When a Stop command is received, the packet that is in the process of being filled will not be completed and transmitted. Only complete packets are sent.

3.1.7.3 ECB Command Acknowledges

Title : Experiment command acknowledges Direction: ECB->RC Protocol: Raw (data is sent as described in this table; no additional EDLF protocol) Frequency: Asynchronous				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	SYNC	2	0x55AA	Sync word
2	Length	2	0x000C	Length of the remainder of the message (unsigned 16 bit)
4	<message fields >			see Table 50 (page 62) for definition of the message contents
..	..	..	..	
14	Checksum	2	0x0000 ..0xFFFF	16-bit addition without carry over all bytes (excluding checksum).

Table 13: ECB command acknowledges

3.1.7.4 ECB Log Messages

Title : Experiment log messages (Errors) Direction: ECB->RC Protocol: Raw (data is sent as described in this table; no additional EDLF protocol) Frequency: Asynchronous				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	SYNC	2	0x55AA	Sync word
2	Length	2	0x001D	Length of the remainder of the message (unsigned 16 bit)
4	<message fields >			see Table 48 (page 61) for definition of the message contents
..	..	..	..	
31	Checksum	2	0x0000 ..0xFFFF	16-bit addition without carry over all bytes (excluding checksum).

Table 14: ECB log messages (errors)

3.1.8 Video Interface (I/F 3)

The Video Interface is a serial RS422 line connecting the Video Control Unit (VCU) to the Rack Controller. It services the Video Assembly.

Data across this interface can be one of the following:

Type	RS422 Electrical Industry Standard	
Settings	19200, 8N1	
Data	From RC to Video	From Video to RC
	Video Commands	Video Health and Status Data
		Log messages
		Command Acknowledges

Table 15: Communications over the Video Interface

3.1.8.1 Video Commands

Title : Video commands Direction: RC->VCU Protocol: EDLF protocol Frequency: Asynchronous				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	Should be filled for command acknowledge
1	Destination	1	ma_VIDEO	
2	Class	1	mc_CMD_AND_ACK +sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: See Table 17	
4	Length	2	parameter length	bytes following this field
6	Parameters	0…32		Optional parameters

Table 16: Video commands

In Table 17 the commands supported by the Video Assembly are listed. A description of the parameters is listed in Table 67 (Appendix C, page 94).

Command	CMD_ID See App B	Description	Parameter length (bytes)
System Time	cmd_SYSTEM_TIME	Sets system time for the Video Assembly. This time is used for time display on the camera(s)	4
Power Control	cmd_POWER_CONTROL	Switches power on/off	2
Video Routing	cmd_VIDEO_ROUTING	Selects input source for monitors and downlink	2
VCR Stop	cmd_VCR_STOP	Sends Stop command to recorder (release tape)	2
VCR Pause	cmd_VCR_PAUSE	Sends Pause command to recorder (hold tape)	2
VCR Play	cmd_VCR_PLAY	Sends Start command to recorder	2
VCR Record	cmd_VCR_RECORD	Sends Record command to recorder (continuous recording)	2
VCR Timelapse	cmd_VCR_TIMELAPSE	Starts timelapse recording. The Video Assembly S/W controls the recording	4
VCR Forward	cmd_VCR_FFWD	Sends Forward command to recorder	2
VCR Rewind	cmd_VCR_REW	Sends Rewind command to recorder	2
Cam Time Overlay	cmd_CAM_TIME_OVERLAY	Enable/Disables automatic overlay of time, shows system time on camera	2
Cam direct command	cmd_CAM_DIRECT	Provides a direct command interface to the camera. The data part of the command is send to the camera literally	32

Table 17: Video command Ids, see also Table 67 (Appendix C, page 94)

3.1.8.2 Video Log messages and Command acknowledges

Log messages are formatted according to the definition described in Table 48 (page 61).
Command Acknowledges are formatted according to the definition described in Table 50, (page 62) with the source field set to *ma_VIDEO_LOG*

3.1.8.3 Video Health & Status data

Title : Video H&S data Direction: VCU->RC Protocol: EDLF protocol Frequency: 1 Hz				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Source	1	ma_VIDEO_HS	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_HOUSEKEEPING	
3	Type	1	mat_HS	
4	Length	2	70	
6	H&S DATA	70	See Table 62, (Appendix C. page 91)	This packet contains status data of all parts of the Video Assembly

Table 18**:** Video H&S data

The video system is required to send H&S data once every second.

3.1.9 CMP (SB) Interface (I/F 4)

The Core Facility Interface is a serial RS422 line connecting the CMP Sensor Board to the Rack Controller. It services the Core Facility.

Data across this interface can be one of the following:

Type	RS422 Electrical Industry Standard	
Settings	19200, 8N1 (fixed)	
Data	From RC to CMP	From CMP to RC
	Status of the different interfaces	Health and Status Data Packets
	Data Flow Control Commands	Command Acknowledges
	SPOE data via RPDA	Log Messages
	Core Facility Commands	
	Time Data	

Table 19: communication overview of CMP interface

3.1.9.1 Health & Status Data

The CMP Sensor Board (SB) sends a fixed length data block

Title : H&S Data Direction: SB ->RC Protocol: EDLF Frequency: 1 Hz				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_SB_HS	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_HOUSEKEEPING	
3	Type	1	mat_HS	
4	Length	2	126	This value is a constant (number of bytes to follow)
6	H&S DATA	126	See Appendix A	This packet contains sensor data of all Core Facility sensors

Table 20: SB H&S data format

The SB is required to send H&S data once every second.

3.1.9.2 MSG System Status data (for display)

The CMP SB receives SPOE status via RPDA and interface status data for displaying. They are intended to provide the MSG user with an overview of the system status via the CMP display
See §3.2.2 (page 64) for details.

3.1.9.3 TOD data

The SB periodically receives time messages containing the Time of Day.
See Table 51 (page 63) for details.

3.1.9.4 Core Facility Commands

Title : Core facility command Direction: RC->CMP Protocol: EDLF Frequency: Asynchronous				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_MLC or ma_ISS_XBUS	
1	Destination	1	ma_SB	
2	Class	1	mc_CMD_AND_ACK +sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: See Table 22	Command Identifier
4	Length	2	2	bytes following this field
6	Parameter	1	See Table 22	Command parameter
7	Not Used	1	N/A	Word alignment

Table 21: Core facility command format

CMD ID See Appendix B for values	Command	Parameter						Parameter Length (in bytes)	Explanation
		Min counts	Min Engineering Units		Max counts	Max Engineering Units			
		Value	Value	Unit	Value	Value	Unit		
cmd_AL_ ILLUMINATION	AlIllumination	0x00	Off		0x01	On		1	Airlock Illumination on/off
cmd_FAN_SP_ SPEED_NORMAL	FanSPSpeed-Normal	0x00	0	Mode	0x07	7	Mode	1	Setpoint Fan Speed Normal Mode
cmd_FAN_ SP_SPEED_ DONNING	FanSPSpeed-Donning	0x01	1	Mode	0x07	7	Mode	1	Setpoint Fan Speed Donning Mode
cmd_PCV_ DONNING	PCVDonning	0x00	Off		0x01	On		1	Donning on/off
cmd_PCV_SP_ NEG_PRESS	PCVSPNeg-Pressure	0x00	0	mbar	0xFF	10	mbar	1	Setpoint Negative Pressure WV
cmd_WV_ ILLUMINATION	WvIllumination	0x00	Off		0x01	On		1	WV Illumination on/off
cmd_WV_ILL_ SP_INTENSITY	WvIllSPIntensity	0x00	40	%	0xFF	100	%	1	Setpoint WV Illumination Intensity
cmd_EXP_1_ PWR_0	Exp1Pwr0	0x00	Off		0x01	On		1	Experiment outlet 1 +5V on/off
cmd_EXP_1_ PWR_1	Exp1Pwr1	0x00	Off		0x01	On		1	Experiment outlet 1 ±12V on/off
cmd_EXP_1_ PWR_2	Exp1Pwr2	0x00	Off		0x01	On		1	Experiment outlet 1 +28V on/off
cmd_EXP_2_ PWR_0	Exp2Pwr0	0x00	Off		0x01	On		1	Experiment outlet 2 +5V on/off
cmd_EXP_2_ PWR_1	Exp2Pwr1	0x00	Off		0x01	On		1	Experiment outlet 2 ±12V on/off
cmd_EXP_2_ PWR_2	Exp2Pwr2	0x00	Off		0x01	On		1	Experiment outlet 2 +28V on/off, see note below
cmd_EXP_PWR_ 120	ExpPwr120	0x00	Off		0x01	On		1	Experiment +120V on/off, see note below
cmd_EXP_PWR_ ICP	ExpPwrICP	0x00	Off		0x01	On		1	ICP + 12V on/off

Table 22: Core Facility commands

3.1.9.5 Log messages and Command acknowledges

Log messages are formatted according to the definition described in Table 48 (page 61).
Command Acknowledges are formatted according to the definition described in Table 50, (page 62) with the source field set to *ma_SB_LOG*

3.1.9.6 Safety data

Part of the Health and Status Data from the CMP/SB is being monitored by the ASW and results in predefined actions when a limit is transgressed. The data monitored includes work volume temperatures and pressure and gas limits. A transgression will set the SB Caution & Warning word when an anomaly is detected.
Refer to §3.3 (MSG DHS Safety data, page 66) for a description of all MSG safety data related issues.

3.1.10 RPDA/AAA (I/F 6)

The Remote Power Distribution Assembly (RPDA) provides the power to all MSG subsystems.
The RPDA is connected to the Rack Controller via the internal MIL1553B bus, as is the MLC. On the internal MIL-bus the RC is Bus Master and the RPDA is a remote terminal. The AAA is only electrically connected to the RPDA; data is acquired and commands are send through the RPDA.
The RPDA has eight slots available for Exchangeable Standard Electronics Modules (ESEM's) and five types of ESEM have been designed to fit in these slots, each with their own power output configuration. Types 1,2,3 and 4 are used in the MSG configuration. Two modules of type 4 (designated 4A and 4B) are present so, together with the cards of the other types, five of the eight slots are used. See [RD6] for details.

Type	MIL1553-B	
Settings	-	
Data	From RC to RPDA	From RPDA to RC
	Analogue Data Acquisition Commands	Data requested
	Digital Data Acquisition Commands	
	Digital Commands	
	Analogue Commands	

Table 23: RPDA interface communications overview.

3.1.10.1 Protocol

This section and the subsections outline the technical details of communications between the RC and the RPDA. Sections 3.1.10.2 and on describe the communication of the RC regarding RPDA and AAA with the external interfaces (i.e. MLC and ISS).
The RC communicates with the RPDA and AAA through ESEM2 as it contains the MIL1553B interface. All other ESEMs are addressed through ESEM2 by specifying the appropriate board address. ESEM2 is also used to retrieve payload data and command. Refer to [AD11] for more detailed information on how to perform commanding and acquisition and on how to address the appropriate ESEM and signal.

Data across the MIL1553B interface can be one of the following:

From RPDA to Rack controller (RPDA->RC):
- Analogue Data Acquisitions (ESEM Temperatures, currents)
- Digital Data Acquisitions (Status bits)
- Payload acquisitions (AAA/SPLC Temperature, AAA rpm)

From Rack controller to RPDA (RC->RPDA):
- RPDA commands (outlet on/off cmds)
- Analogue command (AAA fan speed command)

3.1.10.1.1 Analogue Data Acquisition

Analogue data acquisition of a signal is performed in two steps. First the desired ESEM (BOARD ADDRESS) and signal (CHANNEL ADDRESS) are selected on the RPDA using a 1553 mode code transmission with data word (SYNC mode code). Subsequently the 12-bits digitized data from the selected signal is retrieved from the RPDA via a RT transmit command.
Analogue acquisition from the AAA Payload is performed over ESEM2 (BOARD ADDRESS) and by setting the RPDA/PL bit to 1(PL). The bit is set to 0 (RPDA) when addressing other ESEMs.

RT ADDRESS	T	SUBADDRESS	MODE CODE
FIXED (5 BITS) 00001B =1	0B	11111B or 00000B (MODE)	10001B (SYNC + DATA)

DATA			
000000B	0/1B RPDA/PL	BOARD ADD. (4bits)	CHAN. ADD. (5bits)

RT ADDRESS	T	SUBADDRESS	# OF WORDS
FIXED (5) 00001B=1	1B	11011B	00001B

DATA	
0000B	DATA ACQUIRED (12 BITS)

Figure 4: RPDA Analogue Data Acquisition commands representation

3.1.10.1.2 Digital Data acquisition

Digital data acquisition of a signal is performed in two steps. First the desired ESEM (BOARD ADDRESS) and signal (CHANNNEL ADDRESS) are selected on the RPDA using a 1553 mode code transmission with data word (SYNC mode code). Subsequently the 1-bit data from the selected signal is retrieved from the RPDA via a RT transmit command. RPDA/PL field is always 0.

RT ADDRESS	T	SUBADDRESS	MODE CODE
FIXED (5 BITS) 00001B =1	0B	11111B or 00000B (MODE)	10001B (SYNC + DATA)

DATA			
000000B	0 RPDA	BOARD ADD. (4bits)	CHAN. ADD. (5bits)

RT ADDRESS	T	SUBADDRESS	# OF WORDS
FIXED (5) 00001B =1	1B	11010B	00001B

DATA	
0000000000000000B	DATA ACQUIRED (1 BIT)

Figure 5: RPDA Digital Data Acquisition commands representation

3.1.10.1.3 Digital Commands

Digital data commanding of a signal is performed by a RT receive command. The desired ESEM (BOARD ADDRESS) and signal (CHANNNEL ADDRESS) are selected on the RPDA using a 1553 mode code transmission with data word (SYNC mode code). The 1-bit data for the selected signal is contained in the 1-bit COMM field. RPDA/PL field is always 0.

RT ADDRESS	T	SUBADDRESS	# OF WORDS
FIXED (5) 00001B=1	0B	10101B	00001B

DATA				
00000B	COMM.	0B RPDA	BOARD ADD. (4bits)	CHAN ADD. (5bits)

Figure 6: RPDA Digital commands representation

3.1.10.1.4 Analogue Command

Analogue commanding is only used for setting the AAA speed. Therefore BOARD and CHANNEL address need not be specified.

RT ADDRESS	T	SUBADDRESS	# OF WORDS
FIXED (5) 00001B=1	0B	01010B	00001B

DATA	
0000B	ANALOGUE COMMAND (12 BITS)

Figure 7: RPDA Analogue RPDA commands representation

3.1.10.1.5 Command acknowledges

Command acknowledges are not supported by the RPDA. Reception (and result) of a command can be deduced from the Health & Status data.

3.1.10.2 Health and Status data

The MSG obtains digital and analogue status values from all ESEMS and the AAA and compiles them into a Health and Status message. The message is sent to the router for further distribution.

The data in Table 24 is collected by the RC from the RPDA and reformatted into the message shown in Table 25 before distributing the data.

		ESEM type / Board address				
		E1:1000B	**E2:**0000B	**E3:** 1001B	**E4A**: 1011B	**E4B:** 1101B
Variable	**TYPE**	**Chan. #**	**Chan. #**	**Chan. #**	**Chan. #**	**Chan. #**
Temperature	12-bit Analog	0x01	0x06	0x01	0x01	0x01
Outlet current O1	12-bit Analog			0x02	0x02	0x02
Outlet current O2	12-bit Analog			0x03	0x03	0x03
Outlet current O3	12-bit Analog			0x04		
Outlet current O4	12-bit Analog			0x05		
Main Power voltage	12-bit Analog	0x02				
Analog Reference 5V	12-bit Analog	0x06		0x06	0x06	0x06
AAA Speed	PL 12 bit Analog		0x01			
AAA Delta Pressure	PL 12 bit Analog		0x02			
AAA Current	PL 12 bit Analog		0x03			
AAA Motor Temp	PL 12 bit Analog.		0x04			
AAA Fan Electronics Temp	PL 12 bit Analog		0x05			
SPLC Temperature	PL 12 bit Analog.		0x07			
Module status (OK/Not OK)	1 bit digital	0x00	0x00*	0x00	0x00	0x00
Over-temperature	1 bit digital		0x00*	0x01	0x01	0x01
Outlet 1 command monitor	1 bit digital			0x02	0x02	0x02
DC/DC1 Main Overcurrent	1 bit digital	0x03				
DC/DC2 Main Overcurrent	1 bit digital	0x04				
Main DC/DC Conv.1 (On/Off)	1 bit digital	0x05				
Main DC/DC Conv.2 (On/Off)	1 bit digital	0x07				

Main Power On	1 bit digital	0x09				
Outlet 2 command monitor	1 bit digital			0x03	0x03	0x03
Input Overcurrent	1 bit digital				0x04	0x04
Outlet 3 command monitor	1 bit digital			0x04		
Outlet 4 command monitor	1 bit digital			0x05		
Outlet 1 on	1 bit digital			0x07	0x07	0x07
Outlet 2 on	1 bit digital			0x08	0x08	0x08
Outlet 3 on	1 bit digital			0x09		
Outlet 4 on	1 bit digital			0x0A		
Outlet 1 tripped	1 bit digital			0x0B	0x0B	0x0B
Outlet 2 tripped	1 bit digital			0x0C	0x0C	0x0C
Outlet 3 tripped	1 bit digital			0x0D		
Outlet 4 tripped	1 bit digital			0x0E		
Outlet 1 remote	1 bit digital			0x0F	0x0F	0x0F
Outlet 2 remote	1 bit digital			0x10	0x10	0x10
Outlet 3 remote	1 bit digital			0x11		
Outlet 4 remote	1 bit digital			0x12		
Primary Bus_Off	1 bit digital				0x11	0x11
Primary Bus_Low	1 bit digital				0x12	0x12
Primary Bus_High	1 bit digital				0x13	0x13
Primary Bus_Exc	1 bit digital				0x14	0x14
27V_Trip	1 bit digital				0x15	0x15
29V_Trip	1 bit digital				0x16	0x16
Off Command	1 bit digital				0x17	0x17
Dig Test Out	1 bit digital	0x06		0x06	0x06	0x06

Table 24: RPDA/AAA Health and Status as collected by the RC from the RPDA

* Board status and overtemperature of ESEM 2 are both covered by channel 0x00.

The format of the compiled internal H&S message will be as follows:

Title :	RPDA Health and Status Data as compiled from the data acquired in Table 24
Direction:	RPDA -> RC
Protocol:	None
Frequency:	1 Hz

Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_RPDA_HS	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_HOUSEKEEPING	
3	Type	1	mat_HS	
4	Length	2	114	number of bytes following this field
6	ESEM 1 Temperature	2		
8	ESEM 1Main Power voltage	2		
10	ESEM 1Module status (OK/Not OK)	1		
11	ESEM 1DC/DC1 Main Overcurrent	1		
12	ESEM 1DC/DC2 Main Overcurrent	1		
13	ESEM 1Main DC/DC Conv.1 (On/Off)	1		
14	ESEM 1Main DC/DC Conv.2 (On/Off)	1		
15	ESEM 1 Main Power On	1		
16	ESEM 1 Analog Reference 5V	2		
18	ESEM 2 Temperature	2		
20	AAA Speed	2		
22	AAA Delta Pressure	2		
24	AAA Current	2		
26	AAA Motor Temp	2		
28	AAA Fan Electronics Temp	2		
30	SPLC Temperature	2		
32	ESEM 2 Module status (OK/Not OK)	1		
33	ESEM 3 Module status (OK/Not OK)	1		
34	ESEM 3 Temperature	2		
36	ESEM 3 Outlet current O1	2		
38	ESEM 3 Outlet current O2	2		
40	ESEM 3 Outlet current O3	2		
42	ESEM 3 Outlet current O4	2		
44	ESEM 3 Over-temperature	1		
45	ESEM 3 Outlet 1 command monitor	1		
46	ESEM 3 Outlet 2 command monitor	1		
47	ESEM 3 Outlet 3 command monitor	1		
48	ESEM 3 Outlet 4 command monitor	1		
49	ESEM 3 Outlet 1 on	1		
50	ESEM 3 Outlet 2 on	1		
51	ESEM 3 Outlet 3 on	1		
52	ESEM 3 Outlet 4 on	1		
53	ESEM 3 Outlet 1 tripped	1		
54	ESEM 3 Outlet 2 tripped	1		
55	ESEM 3 Outlet 3 tripped	1		
56	ESEM 3 Outlet 4 tripped	1		
57	ESEM 3 Outlet 1 remote	1		
58	ESEM 3 Outlet 2 remote	1		
59	ESEM 3 Outlet 3 remote	1		

60	ESEM 3 Analog Reference 5V	2		
62	ESEM 3 Outlet remote	1		
63	ESEM 4A Module status (OK/Not OK)	1		
64	ESEM 4A Temperature	2		
66	ESEM 4A Outlet current O1	2		
68	ESEM 4A Outlet current O2	2		
70	ESEM 4A Over-temperature	1		
71	ESEM 4A Outlet 1 command monitor	1		
72	ESEM 4A Outlet 2 command monitor	1		
73	ESEM 4A Overcurrent	1		
74	ESEM 4A Outlet 1 on	1		
75	ESEM 4A Outlet 2 on	1		
76	ESEM 4A Outlet 1 tripped	1		
77	ESEM 4A Outlet 2 tripped	1		
78	ESEM 4A Outlet 1 remote	1		
79	ESEM 4A Outlet 2 remote	1		
80	ESEM 4A Primary Bus_Off	1		
81	ESEM 4A Primary Bus_Low	1		
82	ESEM 4A Primary Bus_High	1		
83	ESEM 4A Primary Bus_Exc	1		
84	ESEM 4A 27V_Trip	1		
85	ESEM 4A 29V_Trip	1		
86	ESEM 4 A Analog Reference5V	2		
88	ESEM 4A OFF Command	1		
89	ESEM 4B Module status (OK/Not OK)	1		
90	ESEM 4B Temperature	2		
92	ESEM 4B Outlet current O1	2		
94	ESEM 4B Outlet current O2	2		
96	ESEM 4B Over-temperature	1		
97	Not used	1		
98	ESEM 4B Outlet 1 command monitor	1		
99	ESEM 4B Outlet 2 command monitor	1		
100	ESEM 4B Overcurrent	1		
101	ESEM 4B Outlet 1 on	1		
102	ESEM 4B Outlet 2 on	1		
103	ESEM 4B Outlet 1 tripped	1		
104	ESEM 4B Outlet 2 tripped	1		
105	ESEM 4B Outlet 1 remote	1		
106	ESEM 4B Outlet 2 remote	1		
107	ESEM 4B Primary Bus_Off	1		
108	ESEM 4B Primary Bus_Low	1		
109	ESEM 4B Primary Bus_High	1		
110	ESEM 4B Primary Bus_Exc	1		
111	ESEM 4B 27V_Trip	1		
112	ESEM 4B 29V_Trip	1		
113	ESEM 4B OFF Command	1		
114	ESEM 4B Analog Reference5V	2		
116	ESEM 1 Digital Test OUT	1		
117	ESEM 3 Digital Test OUT	1		
118	ESEM 4A Digital Test OUT	1		
119	ESEM 4B Digital Test OUT	1		

Table 25: RPDA/AAA H&S format as compiled and distributed by the RC

Note that when in Table 25 the data is 1-bit digital, the value is located in the least significant bit of the byte. Units and scaling of the RPDA and AAA H&S data is not listed in this document and are provided in a separate document describing technical details regarding the MSG RPDA and AAA [RD4].

3.1.10.3 Commands

The RPDA/AAA commands listed in the table below have been identified. These are the commands sent by the RC to the RPDA when a command message according to Table 27 has been received by the RC.

Signal	TYPE	Chan. #	Remarks
ESEM 1 Digital Test IN	1-bit Command	0x06	test command, parameter sent with command is returned in ESEM1 Dig. Test OUT in H&S packet
ESEM 3 Digital Test IN	1-bit Command	0x06	test command, parameter sent with command is returned in ESEM3 Dig. Test OUT in H&S packet
ESEM 3 Outlet O1 On/Off	1-bit Command	0x02	AHU fan motors
ESEM 3 Outlet O2 On/Off	1-bit Command	0x03	Experiment power (120 V/8.3A)
ESEM 3 Outlet O3 On/Off	1-bit Command	0x04	CMP, experiment power (5V,+/- 12V)
ESEM 3 Outlet O4 On/Off	1-bit Command	0x05	AAA, smoke detector
ESEM 4A Digital Test IN	1-bit Command	0x06	test command, parameter sent with command is returned in ESEM4A dig. test out in H&S packet
ESEM 4A Outlet O1 On/Off	1-bit Command	0x02	Laptop connector (28V)
ESEM 4A Outlet O2 On/Off	1-bit Command	0x03	video system
ESEM 4B Digital Test IN	1-bit Command	0x06	test command, parameter sent with command is returned in ESEM4B dig. test out in H&S packet
ESEM 4B Outlet O1 On/Off	1-bit Command	0x02	WV illumination, airlock, SPLC
ESEM 4B Outlet O2 On/Off	1-bit Command	0x03	experiment power (28 V)
AAA Speed (ESEM 2)	12-bit analogue command	N/A	The AAA speed can be set from 1 to 7. The setting corresponds with 12-bit command value: 1 0x1FF 2 0x3FF 3 0x5FF 4 0x7FF 5 0x9FF 6 0xBFF 7 0xDFF

Table 26: RPDA and AAA commands over the internal MIL-bus

For details on the MIL1553 RPDA protocol see 3.1.10.1 and [AD11].

The internal command messages received from the router as send by the external sources like MLC and ISS have the following formatTitle : RPDA/AAA commands
Direction: RC->RPDA/AAA
Protocol: See 3.1.10.1
Frequency: Asynchronous

Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	
1	Destination	1	ma_RPDA	
2	Class	1	mc_CMD+sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: See Table 28	Command Identifier
4	Length	2	See Table 28	parameters
6	Parameter	See Table 28	See Table 28	

Table 27: RPDA/AAA command message format

CMD ID see Appendix B for values	Command name	Parameters			Remarks
		value	offset	Length #bytes	
cmd_ESEM3_O1_ FAN_MOTORS	Fan Motors	On/off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ ESEM3_O2_ EXP_POWER_120V	Exp.Power (120V)	On/off	6	2	1 = on, 0=off, see note below
		<Not Used>	7		Word alignment
cmd_ESEM3_O3_CMP _AND_EXP_12V_5V	CMP and 5V/ +/- 12V exp. power supply to CMP	On/off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ESEM3_O4_AAA_AND_ ASDA	AAA/smoke detector	On/off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ESEM4A_O1_LAPTOP	laptop connector (28V)	On/Off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ESEM4A_O2_VIDEO	WV ill., airlock and SPLC	On/off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ESEM4B_O1_ILLUM_ SPLC_AIRLOCK	WV ill., airlock and SPLC	On/off	6	2	1 = on, 0=off
		<Not Used>	7		Word alignment
cmd_ ESEM4B_O2_ EXP_POWER_28V	Exp.Power (28V)	On/off	6	2	1 = on, 0=off, see note below
		<Not Used>	7		Word alignment
cmd_AAA_SPEED	AAA speed	speed	6	2	The ‘speed’ parameter is a 12-bit value (least significant 12 bits of the 16-bit parameter field). See Table 26 for values
cmd_ESEM1_DIG_TEST_IN	dig I/F test	0/1	6	2	See remarks Table 26
		<Not Used>	7		Word alignment
cmd_ESEM3_DIG_TEST_IN	dig I/F test	0/1	6	2	See remarks Table 26
		<Not Used>	7		Word alignment
cmd_ESEM4A_DIG_TEST_IN	dig I/F test	0/1	6	2	See remarks Table 26
		<Not Used>	7		Word alignment
cmd_ESEM4B_DIG_TEST_IN	dig I/F test	0/1	6	2	See remarks Table 26
		<Not Used>	7		Word alignment

Table 28: RPDA/AAA commands and parameters

Note that commands can be sent to the CMP, which control the power outlets to the WV (Table 22, page 32), apart from the 120V and 28V commands to the RPDA as listed above.

3.1.10.4 Safety Data

Some of the is Health and Status Data from the RPDA/AAA is being monitored by the ASW and results in predefined actions when a limit is transgressed.
Refer to §3.3 (MSG DHS Safety data, page 66) for a description of all MSG safety data related issues.

3.1.11 MLC (I/F 6)

The MLC can be used to operate the MSG facility locally onboard the ISS. The following data can transferred to and from the MLC over the internal MIL-bus (I/F 6):

Type	MIL1553-b	
Settings	**RT address = 21**	
Data	From RC to MLC	From MLC to RC
	Health and Status data (Housekeeping) • SB Health & Status Data • WV (1&2) Health & Status Data • SPOE Health & Status Data • Interface status • MLC Health & status data • Video Health & status data • Log Messages	Commands (MLC->RC) • Core Facility Commands • RPDA Commands • WV Commands • ECB Commands • ASW Internal commands • SSL Internal commands • Video Commands • MLC commands
	Telemetry Data (RC->MLC) • WV Telemetry data • ECB Experiment Telemetry data	MLC Health & Status data
	Experiment commands	Files
	Files	Protocol Flow Control data
	Time Of Day data	

Table 29: MLC interface communications overview

The Internal MIL-bus is a MIL-STD-1553B Bus that connects the Rack Controller to the MLC and runs per design in a master-slave configuration. For the internal MIL-bus the RC is the Bus Master and the MLC is a Remote Terminal: the RC initiates all communication with the MLC. Besides the MLC also the RPDA/AAA is connected to the internal MIL-bus.
Due to the Master-Slave definition of the bus, a different approach is taken for data from RC to MLC as opposed to data from MLC to RC and the mechanism used for both directions is described separately in §3.1.11.1 and §3.1.11.2. In the other subsections the message contents are described.

Each type of data as displayed in Table 29 above is transmitted or received on a particular SA according to the following distribution:

	RC->MLC		MLC->RC	
Data	SA#	section (page)	SA#	section (page)
Commands	1	3.1.11.4.3 (47)	6	3.1.11.3.1 (43)
MLC H&S	-	-	7	3.1.11.3.2 (44)
MSG Housekeeping	2	3.1.11.4.1 (46)	-	-
LRT	3	3.1.11.4.2 (47)	-	-
File data	4	3.1.11.4.4 (48)	8	3.1.11.3.3 (45)
TOD	5	3.1.11.4.5 (48)	-	-
Flow Control data	-	-	30	3.1.11.3.4 (45)

Table 30: Data type distribution over sub addresses on MLC interface with references to the sections describing the layout of the data

3.1.11.1 Protocol description for RC to MLC communications

When transferring data from RC to MLC on one of the SA's in the range 1-5, a length word and sequence counter are added to the data to be transmitted (i.e. a message with MSG header and data), as shown in Figure 8. The resulting block is divided in as much 32-word packets as needed to include all data. These packets are then transmitted over the

designated SA in separate MIL-bus transactions. In the last transaction only the remaining data in the complete block is sent, which is usually less than 32 words.

X * 32 words		0 <= # words <= 31
Length word (*bytes* following)	Seq. counter	data buffer: MSG message (Src., Dst., Class, Type, Length and data)

Figure 8: General block layout for data transfer from RC to MLC

Apart from sending this data, the RC acquires the data from the MLC as specified in Table 35 (page 46), which contains the sequence counters as sent by the RC. As long as the sequence counter last sent to a particular SA in the range 1-4 is not received back by the RC, no new data will be sent to that SA by the RC. Check 3.1.11.3.4 (page 45) for details. Check §3.1.11.3.2 (page 44) for requirements on H&S transmissions by the MLC to the RC.

3.1.11.2 Protocol description for MLC to RC communications

The way in which data is transferred from MLC to RC is slightly different from that in the other direction as described above. Only a length field is added by the MLC to the data, resulting in the layout in Figure 9. Data is acquired only in 32 word packets by the RC, which implies that the MLC pads the block of data to completely fill the packet. The value of the length word does not include the padded data and the length field itself.

X * 32 words		
Length word (only *valid bytes*)	data buffer/ MSG message (Src., Dst., Class, Type, Length and data)	Max 31 words of undefined data

Figure 9: General block layout for data transfer from MLC to RC

The RC acquires the data on a SA in the range of 6 to 8 with a frequency that is SA dependent (see the message layout in the appropriate section as indicated in Table 30 above for the correct frequency). As long as Idle Structure as described in Table 31 is returned to the RC, the RC will discard the data. When the contents of the data received by the RC deviates from the Idle Structure, the RC will treat the data received as part of a block. The RC will start acquiring the data on that SA in a fast loop until the Idle Structure is received again. The MLC is therefore required to transmit at least once the Idle Structure to the RC after transmission of a message to the RC on that same SA.
The concatenated packets are processed and routed to the destination as defined in the enclosed message.
The RC acquires the data on the SA's 6 to 8 only in 32 word packets, never less.

Format of Idle structure in MLC->RC communication				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Word 1	2	0xA5A5	
2	Word 2	2	0xA5A5	
. .	. .	" "	" "	All values 0xA5A5
62	Word 32	2	0xA5A5	

Table 31: Idle Structure format

As mentioned above, the RC acquires the data from the MLC as specified in Table 35 (page 46), which contains the sequence counters as sent by the RC. The first word of the data is the Enable File Data Acquisition word. As long as this word is set, the RC will acquire data from the SA designated for MLC to RC file transfer.
It is the responsibility of the MLC not to overwrite data ready for transmission to the RC until it has been requested by and sent to the RC.

3.1.11.3 Layout of data transfer from MLC to RC

Data is transferred from the MLC to the RC using MIL1553 transmit commands and takes place according to the protocol as described in 3.1.11.2 (page 42). In the subsections of this section the layout of the data transferred is described.

3.1.11.3.1 MLC Commands (MLC->RC)

The format of the commands that can be sent from the MLC is largely identical to those that can be sent from ground (ISS interface), but the source field of the message should read 'ma_MLC' (see appendix B for the numeric value).

The format of commands sent from the MLC is defined in the table below.

Title : Format of command sent from MLC to RC Direction: MLC ->RC Protocol: none Frequency: 5 Hz SA: see Table 30 (page 41)				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2	0x00.. 0x6A	number of bytes following, excluding padding data
2	From here the data block has the same format as specified in the tables describing • CF (Table 21, page 31) or • RPDA/AAA (Table 27, page 39) or • WV (Table 8, page 21) or • ECB (Table 11, page 25) or • ASW (Table 44, page 54) or • SSL (Table 45, page 56) or • Video (Table 16, page 28) or • MLC (format according to this table; command sent is returned to the MLC.) Apart from the MLC, offset starts at 2 in the tables referenced, not zero. **Note that the source field in the headers within these data blocks should be ma_MLC.**			
	Padding	0-63	don't care	padding to fill up the data so the complete block can be divided in 32 word packets

Table 32: Format of command (MLC->RC)

3.1.11.3.2 H&S data from MLC

The MLC can send the following predefined Health & Status data.
The MLC is required to make new H&S data available to the RC once every second. When the H&S data is no longer refreshed, the ASW will regard the MLC as 'Not Communicating', assuming the MLC is no longer connected to the bus. Transmission of data to the MLC and acquiring of data from the MLC, apart from the MLC H&S data, will stop. When the MLC starts sending H&S again transmission and acquisition of data by the RC will resume.
No padding is needed on the MLC H&S data since it fills exactly 8 MIL-bus transactions of 32 words.

Title : MLC H&S Data Direction: MLC ->RC Protocol: none Frequency: 1 Hz SA: see Table 30 (page 41)				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Length	2	254	number of bytes following
2	Source	1	ma_MLC_HS	
3	Destination	1	ma_UNSPECIFIED	
4	Class	1	mc_HOUSEKEEPING	
5	Type	1	mat_HS	
6	Length	2	248	This value is a constant (number of bytes to follow)
8	MLC_DiscreteFire	1		MLC_DiscreteFire represents the fire byte in which experiments without a data system attached can annunciate a fire situation to the space station (see also §3.3, page 66)
9	MLC_Bool0	1		
10	MLC_Ushort0	2		
12	MLC_Ushort1	2		
13	MLC_Ushort2	2		
	…			
254	MLC_Ushort122	2		

Table 33: MLC Health & Status data

3.1.11.3.3 File messages from MLC

The following messages can be sent by the MLC, which apply to file transfer. After reception of the message by the RC it is routed to the destination as defined in the MSG header in the data block.
The layout is very similar to Table 39 (page 48), describing file messages from RC to MLC.

Title :	Format of file messages from MLC to RC			
Direction:	MLC ->RC			
Protocol:	none			
Frequency:	Refer to Table 57 (page 71) for maximum transmission rates of file data messages.			
SA:	see Table 30 (page 41)			
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2		Number of bytes following, excluding padding data
2	From here the data block has the same format with the offset starting at 2, as specified in the tables describing • file transfer start message (Table 56, page 70) or • file data messages (Table 57, page 71) or • file stop messages (Table 58, page 71) **Note that the source field in the headers within these data blocks should be ma_MLC.** The offset starts at 2 in the tables referenced, not zero.			
	Padding	0-63	don't care	padding to fill up the data so the complete block can be divided in 32 word packets

Table 34: Format of file messages (MLC->RC)

3.1.11.3.4 Flow Control data from MLC

For a structured communication from RC to MLC, the MLC is required to provide the data in Table 35 to the RC.
The first word in the structure is used to notify the RC that the MLC has file data to be transferred from MLC to RC. The RC will only acquire data from the SA designated for MLC->RC file transfer when the MLC indicates in this word it has data to send.
The following four words should contain the sequence counter as last sent by the RC as part of a block to a particular SA in the range 1-4. As long as the value last sent to the MLC is not received back by the RC, the RC will send no new data to that SA. This condition does not apply to the situation in which the MLC starts transmitting H&S data, as described in 3.1.11.3.2 (page 44), after it has not sent H&S for some time.
No sequence counter is used on the TOD data sent over SA 5.

Title :	Flow Control Data			
Direction:	MLC ->RC			
Protocol:	none			
Frequency:	12 Hz			
SA:	see Table 30 (page 41)			
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Enable File data acquisition	2	0x00 or 0x01	0x00 = the MLC has no file data to send 0x01 = the MLC does have file data to send
2	SA 1 sequence counter	2	0.. 0xFFFF	Sequence counter as last received on message to SA 1
4	SA 2 Sequence counter	2	0.. 0xFFFF	Sequence counter as last received on message to SA 2
6	SA 3 Sequence counter	2	0.. 0xFFFF	Sequence counter as last received on message to SA 3
8	SA 4 Sequence counter	2	0.. 0xFFFF	Sequence counter as last received on message to SA 4

Table 35: Format of Flow Control data from MLC to RC

3.1.11.4 Layout of data transfer from RC to MLC

Data is transferred from the RC to the MLC asynchronously using MIL1553 receive commands and takes place according to the protocol as described in 3.1.11.1 (page 41). In the subsections of this section the layout of the data transferred is described.

3.1.11.4.1 Health and Status data to MLC

The health & status data of the various subsystems (including the MLC H&S data itself) are packed and sent as one H&S message.

Title :	Format H&S messages from to RC to MLC			
Direction:	RC -> MLC			
Protocol:	none			
Frequency:	1 Hz			
SA:	see Table 30 (page 41)			
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Length	2		Number of bytes following (8 bytes bigger than the value at offset 8)
2	Sequence counter	2	0.. 0xFFFF	The data type of the sequence counter is unsigned short. See the introduction to this section regarding the sequence counter.
4	Source	1	ma_RC	
5	Destination	1	ma_UNSPECIFIED	
6	Class	1	mc_HOUSEKEEPING	
7	Type	1	mat_HS	
8	Length	2		number of bytes to follow
10	From here the message has the same format as specified in section of 3.1.12.1 (page 49) without the CCSDS header; the packet sent is the combination of the packets in §§3.1.12.1.1 to 3.1.12.1.7.			

Table 36: Format of the Housekeeping packet from RC to MLC

3.1.11.4.2 Telemetry data to MLC

The following Telemetry data is sent (in three separate messages) from the RC to the MLC when sampling is enabled for the corresponding sources:

- Direct Experiment Telemetry data from WV1 and WV2,
- ECB Experiment Telemetry data.

Title : Format of telemetry data from RC to MLC Direction: RC -> MLC Protocol: none Frequency: depends on Telemetry sources SA: see Table 30 (page 41)				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2		Number of bytes following this field
2	Sequence counter	2	0x00.. 0xFFFF	The data type of the sequence counter is unsigned short. See the introduction to this section regarding the sequence counter.
4	From here the data block has the same format as specified in Table 47 (page 58) or Table 6 (page 19), describing telemetry. The offset starts at 4, not zero. Note that the sequence counter in the telemetry blocks is another than the one in this table.			

Table 37: Format of the telemetry packet from RC to MLC

No telemetry is generated by the MLC itself.

3.1.11.4.3 Experiment Commands to MLC

The MLC can be used to route commands to experiments in the work volume. The format of these commands is shown in the table below.

Title : Format of telemetry data from RC to MLC Direction: RC -> MLC Protocol: none Frequency: Asynchronous SA: see Table 30 (page 41)				
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2		Number of bytes following this field
2	Sequence counter	2	0x00.. 0xFFFF	The data type is unsigned short. See the introduction to this section regarding the sequence counter.
4	From here the data block has the same format as specified in Table 46, page 57 with the offset starting at 4, not zero			

Table 38: Format of the Housekeeping packet from RC to MLC

3.1.11.4.4 File messages to MLC

The following messages can be sent to the MLC, which apply to file transfer. The layout is very similar to Table 34 (page 45), describing file messages from MLC to RC.

Title :	Format of file messages from RC to MLC			
Direction:	RC -> MLC			
Protocol:	none			
Frequency:	Asynchronous			
SA:	see Table 30 (page 41)			
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2		Number of bytes following, excluding padding data
2	Sequence counter	2	0x00.. 0xFFFF	The data type is unsigned short. See the introduction to this section regarding the sequence counter.
4	From here the data block has the same format with the offset starting at 2, as specified in the tables describing • file transfer start message (Table 56, page 70) or • file data messages (Table 57, page 71) or • file stop messages (Table 58, page 71) The offset starts at 4 in the tables referenced, not zero.			

Table 39: File message layout RC->MLC

3.1.11.4.5 Time Of Day data

Title :	Format of TOD data from RC to MLC			
Direction:	RC -> MLC			
Protocol:	none			
Frequency:	see Table 51 (page 63)			
SA:	see Table 30 (page 41)			
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Length	2		Number of bytes following this field
2	From here the data block has the same format as specified in Table 51 (page 63) with the offset starting at 2, not zero and is sent with the frequency indicated in the same table.			

Table 40: Format of the TOD packet from RC to MLC

The transmission of TOD to the MLC interface can be stopped and started using the appropriate delete and add route commands described in §3.1.12.2.5 (page 53).
Note that there is no sequence counter on the TOD message, as opposed to the other messages, which are sent from RC to MLC.

3.1.11.5 Safety Data

The Health and Status Data from the MLC interface can be monitored by the ASW and could result in predefined actions when a limit is transgressed. By default, MLC_DiscreteFire in the H&S packet is interpreted as the fire detection bit and is monitored by the Rack Controller. When this bit is set, a predefined set of actions will be taken by the ASW. Refer to §3.3 (MSG DHS Safety data, page 66) for a description of all MSG safety data related issues.

3.1.12 ISS Interface (I/F 7)

The Rack Controller (RC) is connected to the ISS MDM/PEP via the External Mil1553B bus, which runs in a master-slave configuration. The RC is a Remote Terminal, while the Station MDM is Bus Master. The Station MDM initiates communication across this interface.

Data sent across this interface can be:

Type	MIL1553-b	
Settings	-	
Data	From RC to ISS	From ISS to RC
	Health and Status data: • SB Health & Status Data • WV (1&2) Health & Status Data • SPOE Health & Status Data • Interface status • MLC Health & status data • Video Health & status data • MSG Log Messages	Commands (ISS->RC) • Core Facility Commands • RPDA Commands • WV Commands • ECB Commands • ASW Internal commands • SSL Internal commands • MLC commands • Video Commands
	Telemetry Data (RC->ISS) • WV Telemetry data • ECB Experiment Telemetry data	files
	files	

Table 41: ISS interface communications overview

All data across this interface utilize CCSDS headers (see §3.5.2, page 74 and [AD5]).

The APID's for downlink data are:

Source	data	APID
MSG	H&S	918
WV1	LRT	945
WV2	LRT	946
ECB	LRT	947

Table 42: APID's for downlink data packets

3.1.12.1 MSG Housekeeping Data (collected)

Health and Status data is collected from the different interfaces and sent in one Housekeeping package to the ISS. The MDM transfers it further to the ground. Health and Status data sent across this interface to the ISS originates from the following sources:

- Core Facility (Sensor Board)
- RPDA/AAA/SPLC
- Experiments (Through direct experiment connection WV1&2)
- ASW (= communication status of the various external interfaces)
- Video
- MLC
- Log Messages

Health & Status data packets of all sources are combined in a single packet with one CCSDS header. Each Health & Status sub-packet within this packet is identified by its SSID. The combined packet is sent with a frequency of 1 Hz. The CCSDS format is described in detail in [AD5].
The contents of the sub-packet are described in the sections below together with their subset IDs. In each packet the 2 words after the SSID word are defined as <reserved>. These are in fact part of the SPT protocol on the external MIL-bus.
The combined packet has the following format:

CCSDS (8 words)	SB H&S	SPOE H&S	WV1 H&S	WV2 H&S	ASW H&S	Video H&S	MLC H&S	Log Messages

At startup all H&S data will be zero by default, until the first H&S of a particular subset is received.
When the status of a particular interface in the ASW H&S packet is no longer 'OK', the H&S data in the corresponding sub-packet should not be regarded as up to date.

3.1.12.1.1 Core facility (SB) Health & Status

SSID word: 64	<2 words reserved>	C&W word	SB Health & status data

The content of the Sensor Board H&S data is defined in Appendix A.

3.1.12.1.2 SPOE Health & Status

SSID word: 65	<2 words reserved>	C&W word	RPDA Health & status data

The content of the RPDA H&S data is defined in Table 25 (page 38), but without the leading 6-byte MSG header. The conditions under which the C&W word is set are defined in §3.1.10.4 (page 40).

3.1.12.1.3 Experiment Health & Status

SSID word: 66 (WV1) or 67 (WV2)	<2 words reserved>	C&W word	WV1/2 Health & status data

The content of the WV1 H&S data is defined in Table 7 (page 20), but without the leading 6-byte MSG header defined in the table.

The format of the WV2 H&S data is identical to that of the WV1 H&S data and is therefore also defined in Table 7 (page 20). It is distinguished from the data of WV1 by it's own SSID. Again the leading 6-byte MSG header is not included. H&S data starts at offset 6.

3.1.12.1.4 ASW Health & Status

SSID word: 68	<2 words reserved>	C&W word	ASW Health & status data

Data Handling System Health and Status contains general information about the MSG system such as the status of the various interfaces. The data field format is as defined in section 3.2.2 (page 64). Again H&S data starts at offset 6 in Table 52 (page 64).

3.1.12.1.5 Video Health & Status

SSID word: 69	<2 words reserved>	C&W word	Video Health & status data

The contents of the Video Health & Status data are defined in Table 18 (page 29).
Note that the leading 6-byte MSG header is again not included. H&S data starts at offset 6 in Table 18.

3.1.12.1.6 MLC Health & Status

SSID word: 43	<2 words reserved>	C&W word	MLC Health & status data

The contents of the MLC Health & Status data are defined in Table 33 (page 44), but note that the leading 8 bytes containing the sequence counter and the 6-byte MSG header is not included. H&S data starts at offset 8.

3.1.12.1.7 Log messages

Log messages are sent to ground and MLC as part of the housekeeping data and are used by MSG to signal events. Events may be Errors, Alarms, Warnings and Information. Note that these 4 categories are *not* related to the C&W word that precedes each sub-packet in the housekeeping! The classification is merely used to differentiate between the log messages themselves. The events are sent in textual form and comprise event type, a source identifier plus additional informational text. Command acknowledges are sent as information events.
The log messages are collected and combined as frames into one housekeeping sub-packet. Frame definitions are given in Table 48 (page 61) and Table 50 (page 62). Distinction between command acknowledge frames and log message frames can be made by the class field in each frame.
Log messages can be generated by the external interfaces like SB, ECB, WV1 and WV2 but also by the ASW and SSL. This part of the housekeeping is not visible to limit checking.

				500 words
SSID word: 44	<2 words reserved>	C&W word	Length word	logging data

The data part of the message is limited to 500 words and the housekeeping packet is generated once every second. However, it is conceivable that in some situations more than 1000 bytes of log data per second is generated by MSG. In that case, log data will be collected up to just below 1000 bytes per second and the last frame will indicate that a number of messages is lost.
The length word indicates the number of valid *bytes* of data in the block, 0 if there is none.

Command acknowledges which are sent by one of the interfaces are distributed as log messages, the Class field in the frame always being mc_ACK_REC in those cases. The string in the log message frame is used to indicate the command that is being acknowledged. Note that the command acknowledge only indicates the successful receipt of the command.

3.1.12.2 Commands

Commands from ground to MSG are routed to MSG over the External MIL1553 Interface via the ISS. The layout for the CCSDS Header is specified in [AD 5]. Command Packets have the following format:

CCSDS Header	MSG Header	Command Field	Checksum

The Command Field includes the parameters, where applicable.
Command acknowledges are sent by the interface and distributed as log messages (part of Housekeeping). In the paragraphs below references to paragraphs describing the contents of the Command Field are given, a listing of the available commands is given in appendix E (page 110). Note that the CCSDS header and Checksum are stripped after verifying their contents.

3.1.12.2.1 Core Facility Commands

The format and content of the MSG header and command field of core facility commands is specified in Table 21 of section 3.1.9.2 (page 31). The source field in this block should be ma_ISS_XBUS (see appendix B for the numeric value).

3.1.12.2.2 RPDA/AAA Commands

The format and content of the MSG header and command field of RPDA/AAA commands is specified in Table 27 of (page 39).). The source field in this block should be ma_ISS_XBUS (see appendix B for the numeric value).

3.1.12.2.3 WV Commands

The format and content of the MSG header and command field of WV commands is specified Table 8 of section 3.1.5.3 (page 21).). The source field in this block should be ma_ISS_XBUS (see appendix B for the numeric value).

3.1.12.2.4 ECB Commands

The format and content of the MSG header and command field of ECB digital commands is specified in Table 11 of section 3.1.7.2 (page 25).). The source field in this block should be ma_ISS_XBUS (see appendix B for the numeric value).

3.1.12.2.5 Internal ASW commands; file transfer (I), telemetry, limit storage and routing

An internal ASW command is a command sent to the ASW itself instead of to one of it's interfaces.
The format of such a command is shown below. Success or failure of any of the commands listed will be signaled by a log message.

Title : ASW Internal Commands (Configuration update) Direction: ISS -> RC (ASW) Protocol: MIL-STD-1553B Frequency: Asynchronous				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	
1	Destination	1	ma_ASW	
2	Class	1	mc_CMD_AND_ACK +sequence counter	See §3.1.2, page 17
3	Type	1	CMD ID: See Table 44	
4	Length	2	0-64	Number of bytes in parameters. (including any terminating 0's)
6	parameters	0-64	See Table 44	String containing the name of the source including terminating. **Must be an even number of bytes!** (add additional 0 if necessary.)

Table 43: Internal commands (Configuration update)

CMD ID (see Appendix B for values)	Parameters			Remarks
name	value	offset	#bytes	
cmd_FILE_UPLOAD	The ID of the destination, maWV1 or ma_WV2	8	2	Upload file command. The ID is an unsigned short. (see A below)
	Name of file including terminating zero	10	<=64 (see I)	
cmd_SW_FILE_FLASH_STORE	Name of software file including terminating zero	8	<=64 (see I)	Command to store the software file in SPLC flash PROM(see B below)
cmd_RAM_DRIVE_INIT (see H below)	device name	8	10	For example "/fd0/" UNIX style, or "C:" in DOS style. Length of parameter is fixed at 10 bytes; terminating 0 indicates actual length.
	number of 512 byte blocks	18	2	<value>*512 is ram drive size in bytes (see E below)
cmd_RAM_DRIVE_REMOVE	device name	8	10	Removes a RAM drive (see cmd_RAM_DRIVE_INIT). **Warning:** any data on 'drive' is lost! (see H below)
cmd_ASW_ADD_ROUTE **or** cmd_ASW_DELETE_ROUTE (see C below)	Source; Refer to the latest version of [RD10] for possible values.	8	<=20 (see I)	String containing the name of the source including terminating 0
	Destination; Refer to the latest version of [RD10] for possible values.		<=20 (see I)	String containing the name of the destination including terminating 0. Offset follows the terminating 0 of 'Source' field

cmd_ROUTE_REPORT	<no parameters>	-	0	Command to list all routes. (see D below)
cmd_OPEN_LRT_CHANNEL	frame rate	8	2	Between 1-100; open LRT channel to ISS (see F and *Requesting LRT bandwidth* below).
cmd_CLOSE_LRT_CHANNEL	<no parameters>	-	0	Close LRT channel
cmd_STORE_USER_LIM_SET	<no parameters>	-	0	Store the current Limit settings (see J below)
cmd_REMOVE_USER_LIM_SET	<no parameters>	-	0	Remove the settings stored with cmd_STORE_USER_LIM_SET (see J below)

Table 44: Internal ASW commands

The following comments apply to the information in the table above:

A. The File Upload command causes the ASW to initiate the file transfer from SPLC RAM to one of the WV interfaces. Note that this file first must be downloaded to the RC. See §3.1.10.3 (page 39) for a description and details regarding file transfer by the MSG DHS.

B. The Flash Store command stores a previously to the SPLC RAM uploaded VxWorks object file into the flash PROM of the SPLC. This makes it possible to add or replace the software present on the SPLC.

C. With the Add and Delete Route commands the routing of data between a source (for instance telemetry) and a destination (for instance the MLC) can be stopped or started. These changes are not permanent; rebooting the RC will restore the defaults. Not every combination of Source and destination is valid. See [RD10] for details.

D. The Route Report causes the ASW to format log messages containing information about the data routes existing between various interfaces and software modules. This information can then be used to change the routing table, (see section 3.1.12.2.5, page 53).

E. The size of the RAM drive is limited by the amount of free memory on the RC. A minimum size of 1024 blocks (=500KB) is guaranteed.

F. The LRT Channel Open command is mandatory before any LRT generated by the MSG (i.e. ECB or WV telemetry data) can be sent to ground. It sends out a request to the BC on the external MIL-bus (i.e. PEP) for LRT bandwidth. This command is buffered inside the BSW until the first attempt is made to send LRT. It is therefore recommended to shortly enable the ECB to send LRT data. If the subsequent request for LRT bandwidth is refused, no LRT will be received and a log message will be generated. By forcing LRT to be sent in this way, the risk of not receiving vital LRT of an experiment is minimalized.
This command will fail if an LRT channel is already open to the MSG[1].
See also *Requesting LRT bandwidth* below.

G. Take notice of the fact that LRT data up to 10 seconds can be buffered inside the RC. So do not close the LRT channel directly after transmission of LRT by the ECB or one of the WV interfaces is stopped, else data may be lost.

H. The commands cmd_RAM_DRIVE_INIT and cmd_RAM_DRIVE_REMOVE are used to initialize/install and subsequently remove a virtual RAM drive in the SPLC memory. A Ram drive is needed when transferring files to the RC from, for example, a WV interface.

I. As described in §2.3 on page 16, all communications of the external MIL-bus to the ISS must be word aligned. It is therefore the responsibility of the sender on the ground to word align a route command to the SPLC. In case the sum of the number of bytes in Source and Destination (including the terminating zeros) is uneven, an additional zero should be added and the value of the length field increased by 1. The same applies to the file commands.

J. With the command cmd_STORE_USER_LIM_SET the current limit checking parameters are stored on the RC. After reboot these settings will then be restored. With the command cmd_REMOVE_USER_LIM_SET the stored settings are removed from the RC, making the settings described in §3.3 (MSG DHS Safety data, page 66) the default settings again.

[1] the option in the SPT protocol to open an LRT channel per sub-packet in the H&S data [AD5] is not supported by the BSW and therefore not available to MSG.

3.1.12.2.5.1 Requesting LRT Bandwidth

In the table above the command cmd_OPEN_LRT_CHANNEL is specified which must be used before an attempt is made to send LRT from MSG. The value of the frame rate parameter specifies the number of frames MSG will transmit per **10** seconds. The frame rate concerns the use of LRT bandwidth on the external MIL-bus and is described in detail in [AD5].
For each ECB or WV telemetry message one frame is used. The frame rate needed should be calculated by determining what LRT sources in the MSG will be used, adding up the number of messages they generate *per10 seconds* (see Table 6 on page 19 and Table 47 on page 58). Claiming less bandwidth than necessary will inevitably lead to the loss of telemetry data over the connection to ground.
When more bandwidth has been claimed (and granted) than needed, the last frame of LRT data will be retransmitted over the external MIL-bus until a new LRT frame is supplied to the BSW.
Take note of the fact that it is not possible to claim a different bandwidth without closing any existing bandwidth.
The issues described here do not influence the flow of LRT data to the MLC since the MLC is on the internal MIL-bus.

3.1.12.2.5.2 Command acknowledges

Command Acknowledges are formatted according to the definition described in Table 50, (page 62) with the source field set to *ma_ASW_LOG*.

3.1.12.2.6 Internal SSL Commands: File Transfer(II) and Monitoring

A number of commands that can be sent to the MSG are not handled by the ASW, but by a part of the BSW called the SPLC Service Layer (SSL).
Below the message format of these commands is described, which is in one detail different from all other messages defined in this document: a length field is not included.
The commands needed to operate the MSG facility are:

- File commands related to the upload of software and storage in flash PROM, or related to the upload/download of files to the direct work volume interfaces (WV1 and WV2).
  - SSL_CMD_FILE_USL_FT_uploadStart; Initiate an upload of a file to the US-Lab DMS.
  - SSL_CMD_FILE_USL_FT_downloadStart; Initiate a download of a file from the US-Lab DMS.

  Additional file handling commands[2] are available, but these are of limited use since the SPLC in the MSG has no mass storage.
- Monitor commands related to enabling/disabling limit checking on H&S parameters and setting of limits
  - SSL_CMD_MON_setLimitsBOOL Set the limits of a monitored parameter of type BOOL
  - SSL_CMD_MON_setLimitsUINT Set the limits of a monitored parameter of type UINT
  - SSL_CMD_MON_setLimitsINT Set the limits of a monitored parameter of type INT
  - SSL_CMD_MON_setLimitsFLOAT Set the limits of a monitored parameter of type FLOAT
  - SSL_CMD_MON_getAttribs Retrieve the attributes of a monitored parameter. The SSL issues an event message to the ASW which contains the attributes. This message is converted into a log message by the ASW according to §3.1.16.1 (page 61) and distributed in the H&S data.
  - SSL_CMD_MON_enablePar Enable/disable the monitoring of a parameter.
  - SSL_CMD_MON_setViolations Set the number of violations until a monitor action is performed.
- A reboot command
  - SSL_CMD_TASK_reboot; Reboot the SPLC

Further details like numerical values and parameters regarding these commands can be found in Appendix B of the BSW ICD [AD8]. Note that events described in [AD8] are converted to log messages by the ASW and thus distributed in the H&S data.

[2] e.g. making and deleting directories, deleting and moving files and listing of files

With regard to the SSL_CMD_MON_setLimits commands: these commands allow to set high and low, alarm[3] and warning limits for each H&S parameter. A warning indicates that an undesirable situation has arisen and an alarm is likely to occur in the near future. An alarm indicates a serious situation, possibly requiring a ground/crew response. In case a limit transgression occurs (alarm or warning), a log message will be formatted and sent to MLC and ground containing the parameter ID, an indication of alarm or warning, the current value of the parameter and its limit. In case of a limit transgression (alarm or warning), some automated procedures defined in the ASW will be carried out. See §3.3 on page 66 for more information.

Title : SSL Commands (Configuration update) Direction: ISS -> RC (SSL) Protocol: MIL-STD-1553B Frequency: Asynchronous				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_ISS_XBUS or ma_MLC	**No length field included**
1	Destination	1	ma_SSL	
2	Class	1	mc_CMD_AND_ACK +sequence counter	see §3.1, page 17 (*)
3	Type	1	CMD ID	See appendix B of [AD8]
4	parameters	See [AD8], appendix B	See [AD8], appendix B	Route command + Source + Destination (including terminating 0's)

Table 45: Command message format for SSL commands (setting limits/file transfer).

* The SSL supports other acknowledge options for the class field than the ASW does. But it is strongly recommended to use the value displayed in this table for consistent behavior of the MSG DHS.

3.1.12.2.6.1 SSL Command acknowledges and SSL Log messages

Note that events described in [AD8] are converted to log messages by the ASW according to the general ASW definition on 3.1.16.1 (page 61) and thus distributed in the H&S data, but with one exception. When the event ID is SSL_EVENT_CMDACK_RECEIVED, it will be converted to a command acknowledge log message according to 3.1.16.2 (page 62).

[3] distinguish this alarm and warning from the C&W word in the housekeeping packet. Here they are used internally in the limit checking component to indicate the transgression of a limit. But the action connected to this transgression might in turn set the C&W to a predefined value

3.1.12.2.7 Direct Experiment Commands

The MLC can be used to route commands to experiments in the work volume. The format and content of these commands is specified in the table below.

Title : Experiment commands Direction: ISS->MLC Protocol: None Frequency: Asynchronous				
Offset (bytes)	Field Name	# bytes	Value	Remarks
0	Source	1	ma_ISS_XBUS	
1	Destination	1	ma_MLC	
2	Class	1	mc_CMD +sequence counter	see §3.1, page 17
3	Type	1	CMD ID: 0x00..0xFF	Experiment specific
4	Length	2	Parameter Length	bytes to follow this field
6	Parameters	0..100		Optional parameter(s) Must be an even number of bytes!

Table 46: Direct experiment commands

3.1.12.2.8 Video Commands

The format and content of the MSG video commands is specified in Table 16 (page 28). The source field in this data block should read ma_ISS_XBUS (see appendix B for the numeric value).

3.1.12.3 Telemetry data

Telemetry data collected by MSG is sent to the ground via the MIL1553 link to ISS (Low rate Telemetry). The ISS is responsible for routing the data to the ground.
All Messages have the following format:

CCSDS HDR	Telemetry data

The layout for the 8-word CCSDS Header is specified in [AD5].

The Telemetry data block is filled with data from the following sources, described in the following subsections:

- Experiment Control Board (up to 8 analogue and 8 digital channels acquired from the WV.)
- WV (through WV1 and WV2 serial connections)

Before LRT can be transmitted to ground an LRT channel must be opened using the cmd_OPEN_LRT_CHANNEL as described in §3.1.12.2.5 (page 53). Check the notes given in the section mentioned and §3.1.12.2.5.1(Requesting LRT Bandwidth, page 55) for constraints.

3.1.12.3.1 ECB Telemetry data

The Experiment Control Board telemetry data contains the (12 bits) digitised values of 0 to 8 analogue channels and 0 or 8 digital 1-bit signals measured by the ECB in the MSG work volume.
The format & contents of the MSG Header and data for ECB Telemetry data is based on the data described in section 3.1.7.1, page 22, with the addition of TOD, resulting in the following message:

Title :	Experiment telemetry data			
Direction:	RC->ISS			
Protocol:	MIL1553b			
Frequency:	See Table 10 (page 23)			
Offset (bytes)	Field Name	#bytes	Value	Remarks
0	Source	1	ma_ECB_LRT	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_TELEMETRY	
3	Type	1	mat_UNSPECIFIED	
4	Length	2	1016	number of bytes to follow
6	Sequence counter	2	0..0xFFFF	Increased by one each new telemetry message
8	ASW TOD- Century	1	BCD20	BCD Notation !
9	ASW TOD- Year	1	BCD00..BCD99	
10	ASW TOD- Month	1	BCD01..BCD12	
11	ASW TOD- Day	1	BCD01..BCD31	
12	ASW TOD- Hours	1	BCD00..BCD23	
13	ASW TOD- Minutes	1	BCD00..BCD59	
14	ASW TOD- Seconds	1	BCD00..BCD59	
15	Not Used	1		Word alignment
16	Milliseconds	2	0 .. 999	Unsigned 16 bit milliseconds counter.
18	Included Analogue channels	1	Bit pattern LSBit (0) = chan 1 MSBit (7) = chan 8 (0 = incl., 1=excl.)	Number of channels sampled data
19	Included Digital channels	1	0 = no dig.channels 1=8 digital channels	Number of digital channels in sampled data
20	Frequency	1	0x01..0xFF	
21	Not Used	1		Word alignment
22	DATA	1000		

Table 47: ECB telemetry data

3.1.12.3.2 Direct Work Volume Telemetry data

Direct Work Volume Telemetry data is received from two serial connections (WV1 and WV2)
The format & contents of the MSG Header and data for WV1 Telemetry data is described in Table 6 (page 19).
Data formats for WV2 Telemetry data are identical to those of WV2 except for the source field in the MSG header. Here the letter combination 'ma_WV1_LRT' is replaced by 'ma_WV2_LRT'.

3.1.12.4 Safety Data

On top of the hardware controlled safety measures the MSG provides a two-stage software anomaly detection mechanism. It allows for early detection of situations that may lead to an automatic hardware controlled action and of other anomalies in the MSG facilities. Monitoring of these parameters is therefore performed by the MSG ASW and does not require the monitoring services of the ISS MDM/PEP. The C&W word of the appropriate Health and Status data set (identified by its Sub Set ID) is set to the required value by the monitoring service upon detection of an anomaly.
The details of what limits are monitored and what the predefined actions are taken upon a transgression, are described in §3.3 (MSG DHS Safety data, page 66)

3.1.13 Test Serial Interface (I/F 9)

The purpose of this interface is to have a direct connection to the VxWorks kernel of the RC. This interface can be used for a low level test and checkout of the RC. The interface is used for running an ASCII text based terminal for direct access to the VxWorks operating system and an interface to the boot program.

3.1.14 S/W Development Ethernet (I/F 10)

This IEEE 802.3 Ethernet interface is used during software development for easy software downloading access to the development system. It is also used during the test and checkout phase by the EGSE through PaCTS (Payload Computer Test System) for validation and verification purposes.

3.1.15 Payload Ethernet (I/F 11)

This IEEE 802.3 Ethernet connection falls outside the scope of the MSG Data Handling System as it is just the interface wiring that is present from the MSG Core Facility to the ISS Utility Interface Panel. As such it is not an actual interface but more or less a feed through. It is mentioned here for completeness.

3.1.16 Log and Command Acknowledge message definition

Those interfaces that support logging and command acknowledges all share the same message format definition, as described below. These messages are combined into one packet and sent to the ISS/ground and MLC as part of the housekeeping data and is described in §3.1.12.1.7 (page 51).
The amount of log data that can be sent over the interface to the ISS/ground is limited. When more data is generated than the space available, log data will be lost. If each interface capable of generating log and/or command acknowledge message generates no more than 120 bytes of log messages according to the format described below, all log data will be transmitted.

3.1.16.1 Log messages

Title : General Log Message format Direction: WV1,WV2, ECB, SB, VCU, SSL or ASW -> RC Protocol: EDLF (ECB: raw) Frequency: Asynchronous				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	see Table 49	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_LOG	
3	Type	1	mat_UNSPECIFIED	
4	Length	2	2+Length(Text Message)	including terminating NULL
6	Error Code	1	see Table 49	Source specific
7	Severity	1	See appendix D	
8	Text Message	see Table 49	Text string	string, including terminating NULL

Table 48: General log message definition

when Interface is:	Source	Error Code
WV1 or WV2	ma_WV1_LOG	0x00..0xFF, Experiment specific
ECB	ma_ECB_LOG	See appendix D
VCU	ma_VIDEO_LOG	See appendix D
SB	ma_SB_LOG	See appendix D
ASW	ma_ASW_LOG	See appendix D
SSL	ma_SSL_LOG	See appendix D

Table 49: Possible error codes depending on source

3.1.16.2 Command acknowledges

Title :	General Command Acknowledge Message Format			
Direction:	WV1,WV2, ECB, SB, VCU, SSL or ASW -> RC			
Protocol:	EDLF (ECB: raw)			
Frequency:	Asynchronous			
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_WV1_LOG, ma_WV2_LOG, ma_ECB_LOG, ma_VIDEO_LOG, ma_SB_LOG, ma_SSL_LOG , ma_ASW_LOG or ma_SSL_LOG	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_ACK_REC	
3	Type	1	mat_UNSPECIFIED	
4	Length	2	4	
6	Original Source	1		Source field of acknowledged command
7	Original Destination	1		Destination of acknowledged command
8	Original Class	1		Class of acknowledged command
9	Original Type	1		Command ID of acknowledged command

Table 50: General Command acknowledges

The command acknowledges only confirms the successful reception of a command and is in fact a special case of the general log message.
The effect of the command should be deduced from the H&S data and/or subsequent log messages.

3.2 Internal Interface Description (Block Definitions)

This section describes the detailed interface definitions of all internal interfaces i.e. those interfaces that connect internal ASW components.

3.2.1 TOD data

The ASW periodically generates time messages and distributes them to all components that need to be aware of the time, i.e. MLC, WV1&2 and CMP. The TOD message is based on the SPLC internal system. The clock is frequently updated (by the BSW) using the Broadcast Time Data on the external MIL-bus. The data format will be as follows:

Title : Time of Day Data Frequency: 1Hz				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_RC	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_SYSTEM	
3	Type	1	mat_TIME	
4	Length	2	8	
6	ASW TOD- Century	1	BCD20	BCD Notation
7	ASW TOD- Year	1	BCD00..BCD99	
8	ASW TOD- Month	1	BCD01..BCD12	
9	ASW TOD- Day	1	BCD01..BCD31	
10	ASW TOD- Hours	1	BCD00..BCD23	
11	ASW TOD- Minutes	1	BCD00..BCD59	
12	ASW TOD- Seconds	1	BCD00..BCD59	
13	Not used	1		Word alignment

Table 51: TOD data format

3.2.2 ASW Status

The ASW generates messages containing the status of its interfaces. The format is as follows:

Title : ASW status Frequency: Asynchronous				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_STATUS_HS	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_STATUS	
3	Type	1	mat_IF	
4	Length	2	8	
6	ECB I/F status	1	0=Not OK 1=OK 2=No Comm.	
7	SB I/F status	1	0=Not OK 1=OK	
8	WV1 I/F status	1	0=Not OK 1=OK 2= No Comm.	
9	WV2 I/F status	1	0=Not OK 1=OK 2= No Comm.	
10	Video I/F status	1	0=Not OK 1=OK 2= No Comm.	
11	Int. MIL1553-RPDA I/F status	1	0=Not OK 1=OK	
12	ISS I/F status	1	0=Not OK 1=OK	
13	Int. MIL1553-MLC I/F status	1	0=Not OK 1=OK 2= No Comm.	

Table 52: ASW Interface Status message

The interface status indicates the result of the last communication transaction performed. The status turns to Not Ok when a transaction fails and returns to OK after successful completion of a new transaction. The status does not necessarily reflect the hardware status; it merely indicates if the software is able to perform a call to the interface.

3.2.3 SPOE status

The ASW generates messages containing a global overview of the status of the RPDA ESEMS, the AAA and the SPLC temperature. The format is as follows:

Title : RPDA status data Frequency: 1 Hz				
Offset (bytes)	Field Name	Number of bytes	Value	Remarks
0	Source	1	ma_STATUS_ESEM	
1	Destination	1	ma_UNSPECIFIED	
2	Class	1	mc_STATUS	
3	Type	1	mat_ESEM	
4	Length	2	52	length of remainder of the message
6	<Not Used>	1		word alignment
7	ESEM 1 status	1	0 = Not OK; 1 = OK	RPDA
8	ESEM 2 status	1	0 = Not OK; 1 = OK	,,
9	ESEM 3 status	1	0 = Not OK; 1 = OK	,,
10	ESEM 4A status	1	0 = Not OK; 1 = OK	,,
11	ESEM 4B status	1	0 = Not OK; 1 = OK	,,
12	ESEM 1 Temperature	2		,,
14	ESEM 2 Temperature	2		,,
16	ESEM 3 Temperature	2		,,

18	ESEM 4A Temperature	2		,,
20	ESEM 4B Temperature	2		,,
22	ESEM 3 Outlet O1 On/Off	1		,,
23	ESEM 3 Outlet O2 On/Off	1		,,
24	ESEM 3 Outlet O3 On/Off	1		,,
25	ESEM 3 Outlet O4 On/Off	1		,,
26	ESEM 4A Outlet O1 On/Off	1		,,
27	ESEM 4A Outlet O2 On/Off	1		,,
28	ESEM 4B Outlet O1 On/Off	1		,,
29	ESEM 4B Outlet O2 On/Off	1		,,
30	ESEM 3 Outlet O1 Current	2		,,
32	ESEM 3 Outlet O2 Current	2		,,
34	ESEM 3 Outlet O3 Current	2		,,
36	ESEM 3 Outlet O4 Current	2		,,
38	ESEM 4A Outlet O1 Current	2		,,
40	ESEM 4A Outlet O2 Current	2		,,
42	ESEM 4B Outlet O1 Current	2		,,
44	ESEM 4B Outlet O2 Current	2		,,
46	AAA Speed	2		AAA
48	AAA Motor Temp	2		,,
50	AAA Fan Electronics Temp	2		,,
52	AAA Delta Pressure	2		,,
54	AAA Current	2		,,
56	SPLC Temperature	2		through RPDA

Table 53: RPDA and AAA status message. Check [RD4] for meaning of the values provided.

The status variables listed are extracted from the data shown in Table 24 (page 36).

3.3 MSG DHS Safety data

Safety data is understood to be data from a payload and part of the H&S data that has to be transmitted to the Station MDM so that, in case of a safety critical situation, the Station MDM can undertake actions to correct or prevent such situations from occurring.
The BSW layer supplies a mechanism for limit checking in which an upper and lower high limit and an upper and lower low limit can be set for each individual H&S parameter. When one of the limits is transgressed and monitoring of that parameter is enabled, a predefined action will be taken. In the table below that action is indicated. When no particular action is indicated only a log message will be generated.
All the limits themselves can be changed by remote command as can the limit checking of an individual parameter be enabled or disabled. Also the number of times the limit must be transgressed before the action is performed can be set by command. The commands to do this are described briefly in §3.1.12.2.6 (page 55).
The action to be taken upon transgression of a limit is fixed and cannot be changed by remote command.
In the table below the data that is being monitored is grouped by the interface source, which can be

- Sensor Board data
- RPDA Data
- WV1/WV2 Data
- MLC data

The third column of the table indicates to what value the C&W word is set when a particular limit is transgressed. The C&W word is located in the corresponding sub-packet in the total Housekeeping packet as described in §3.1.12.1 (page 49). The fourth column refers to Table 55, showing which action is connected to a limit.

Signal/parameter	Limit	C&W word	H/W S/W*	Action-> Table 55	Remark
↓ Source: WV1 H&S, §3.1.5.2, page 20					
WV1_H&S_Discrete Fire	=1	Caution	S/W	A	
↓ Source: WV2 H&S, §3.1.5.2, page 20					
WV2_H&S_Discrete Fire	=1	Caution	S/W	A	
↓ Source: MLC H&S, §3.1.5.2, page 20					
MLC_DiscreteFire	>0	Caution	S/W	A	
↓ Source: SB H&S, §3.1.9.1, page 30 and appendix A					
Work Volume Temperature	> 47 °C	Advisory	S/W		
Work Volume Temperature	> 51 °C	Caution	S/W	A	
Fb1Pressure1Lim	dP (FF) < 1 mb OR dP (FF) > 10 mb	Advisory	H/W		
Fb1Pressure2Lim	dP (RF) < 1 mb OR dP (RF) > 10 mb	Advisory	H/W		
Fb1Gas1Lim	G(FF)(T/H-corrected)>1000ppm	Advisory	H/W		
Fb1Gas2Lim	G(RF)(T/H-corrected)>1000ppm	Advisory	H/W		
Fb1HumidityLim	Hum (T-corrected) > 70%	Advisory	H/W		
Fb2Pressure1Lim	dP (FF) < 1 mb OR dP (FF) > 10 mb	Advisory	H/W		
Fb2Pressure2Lim	dP (RF) < 1 mb OR dP (RF) > 10 mb	Advisory	H/W		
Fb2Gas1Lim	G(FF)(T/H-corrected)>1000ppm	Advisory	H/W		
Fb2Gas2Lim	G(RF)(T/H-corrected)>1000ppm	Advisory	H/W		
Fb2HumidityLim	Hum (T-corrected) > 70%	Advisory	H/W		
Fb3Pressure1Lim	dP (FF) < 1 mb OR dP (FF) > 10 mb	Advisory	H/W		
Fb3Pressure2Lim	dP (RF) < 1 mb OR dP (RF) > 10 mb	Advisory	H/W		

Fb3Gas1Lim Fb3Gas2Lim Fb3HumidityLim	G(FF)(T/H-corrected)>1000ppm G(RF)(T/H-corrected)>1000ppm Hum (T-corrected) > 70%	Advisory Advisory Advisory	H/W		
WvEBTemp	>50°C	Advisory	S/W		
WvEBTemp	>55°C	Caution	S/W	B	
WvPressureLim WvAirTempLim WvBPressureSel WvHumidityLim	dP < 1.3 mb T air > 49°C Backup Pressure sensor selected Humidity (T-corrected) > 70%	Advisory Advisory Advisory Advisory	H/W H/W H/W H/W		
AlPressureLim	dP < 1 mb OR dP > 10 mb	Advisory	H/W		
OHD1 OHD2 OHD3 OHD4	Overheat Detection 1 >70°C Overheat Detection 2 >70°C Overheat Detection 3 >70°C Overheat Detection 4 >70°C	Caution Caution Caution Caution	H/W H/W H/W H/W		WV clixon trip;H/W in CF inhibits all experiment power outlets from the CMP **
CpTemperatureLim MTLTemperatureLim	T coldplate > 49°C T MTL out > 28°C	Caution Caution	H/W H/W		H/W controlled inhibition of all exp. power outs of the CMP
OpenMode	Open Mode	Advisory	H/W		
DCBoxTemp	>70°C	Advisory	S/W		
DCBoxTemp	>75°C	Caution	S/W	B	
CMP Processors	Stopped	Warning	NA		Manual reset CMP (det. on stop SB H&S data)
↓ Source: SPOE (RPDA/AAA) H&S, §3.1.10.2, page 35					
ESEM 1 Temperature	> 70°C	Advisory	S/W		
	> 72°C	Caution	S/W	C	SPLC loses power
ESEM 2 Temperature	> 70°C	Advisory	S/W		
	> 72°C	Caution	S/W	C	SPLC loses power
ESEM 3 Temperature	> 70°C	Advisory	S/W		
	> 72°C	Caution	S/W	B	
ESEM 4A Temp.	> 70°C	Advisory	S/W		
	> 72°C	Caution	S/W	D	
ESEM 4B Temp.	> 70°C	Advisory	S/W		
	> 72°C	Caution	S/W	B	
ESEM 1 overcurrent	Overcurrent	Advisory	H/W		
ESEM 1DC/DC1 Main Overcurrent	>200%	Advisory	H/W		redundant circuit lost
ESEM 1DC/DC2 Main Overcurrent	>200%	Advisory	H/W		redundant circuit lost
ESEM 3 Overtemp alarm	>75°C	Caution	H/W	B	The ESEM 3 outlets are automatically switched off
ESEM 3 outlet 1/2/3/4 Trip		Caution	H/W		4 separate variables
ESEM 4A Overtemp alarm	>75°C	Caution	H/W		The ESEM 4A outlets are autom. switched off
ESEM 4A Input Overcurrent	>20A	Caution	H/W		The ESEM 4A outlets are autom. switched off
ESEM 4A outlet 1 / 2 Trip		Caution	H/W		two separate variables

ESEM 4B Overtemp alarm	>75°C	Caution	H/W		The ESEM 4B outlets are automatically switched off. SPLC loses power; communication and remote control are lost
ESEM 4B Input Overcurrent	> 20 A	Caution	H/W		The ESEM 4B outlets are automatically switched off. SPLC loses power; communication and remote control are lost
ESEM 4B outlet 1 / 2 Trip		Caution	H/W		two separate variables
ESEM 1/2/3/4A/4B Module stat	Not Ok	Advisory	HW		4 separate variables
SPLC Temperature	>70°C	Advisory	S/W		
	>72°C	Caution	S/W	C	SPLC loses power
AAA Fan electronics temperature	>70°C	Advisory	S/W		
	>75°C	Caution	S/W	C	SPLC loses power
AAA Motor Temperature	>70°C	Advisory	S/W		
	>75°C	Caution	S/W	C	SPLC loses power

Table 54: MSG Safety data overview

* The column “H/W S/W” indicates whether a limit is hardware defined, and therefore unchangeable, or software defined, and can be changed by the appropriate command (see 3.1.12.2.6, page 55). However, not all commands indicated as H/W limits from the SB interface are strictly HW limits. Some of those are defined in the ESW of the CMP. These are stored in EEPROM and can therefore not be changed by remote command.
** The four overheat detectors in the work volume are logically OR’ed together; experiment power is switched off when one of the four units trips. The combination of these four OHD’s is also referred to as the ‘WV clixon trip’. The measures taken are the same as action A, but taken by H/W instead of the RC S/W.

ACTION A	**ACTION B**
The following commands (from Table 22, page 32) with the parameter set to 'off' are sent to the CMP: • cmd_EXP_1_PWR_0 (EXPT OUTLET 1 +5V) • cmd_EXP_1_PWR_1 (EXPT OUTLET 1 + - 12V) • cmd_EXP_1_PWR_2 (EXPT OUTLET 1 +28V) • cmd_EXP_2_PWR_0 (EXPT OUTLET 2 +5V) • cmd_EXP_2_PWR_1 (EXPT OUTLET 2 + - 12V) • cmd_EXP_2_PWR_2 (EXPT OUTLET 2 +28V) • cmd_EXP_PWR_120 (EXPT OUTLET 3 +120V) • cmd_EXP_PWR_ICP(ICP +12V)	The following commands (Table 22, page 32) with the parameter set to 'off' are sent **in this order** to the CMP: • cmd_WV_ILLUMINATION • cmd_AL_ILLUMINATION The following commands (from Table 28, page 40) with the parameter set to 'off' are sent to the RPDA: • cmd_ESEM3_O1_FAN_MOTORS • cmd_ ESEM3_O2_EXP_POWER_120V • cmd_ESEM3_O3_CMP_AND_EXP_12V_5V • cmd_ ESEM4B_O2_EXP_POWER_28V
ACTION C	**ACTION D**
The following commands (from Table 28, page 40) with the parameter set to 'off' are sent **in this order** to the RPDA: • cmd_ESEM3_O1_FAN_MOTORS • cmd_ ESEM3_O2_EXP_POWER_120V • cmd_ESEM3_O3_CMP_AND_EXP_12V_5V • cmd_ESEM4A_O1_LAPTOP • cmd_ESEM4A_O2_VIDEO • cmd_ ESEM4B_O2_EXP_POWER_28V • cmd_ESEM3_O4_AAA_AND_ASDA • cmd_ESEM4B_O1_ILLUM_SPLC_AIRLOCK **Note:** power to the SPLC is lost, and with it remote control of and communication with the MSG facility.	The following commands (from Table 28, page 40) with the parameter set to 'off' are sent to the RPDA: • cmd_ESEM4A_O1_LAPTOP • cmd_ESEM4A_O2_VIDEO

Table 55: Predefined actions to be taken by the MSG DHS when a particular limit is transgressed. Numerical values of the commands given can be found in Appendix B of this document.

3.4 File Transfer

File Transfers between the RC and one of the WV interfaces or between one of the WV interfaces and the MLC (via the RC interfaces) or between the RC and the MLC uses three types of messages, shown schematically in the following figure.
File downloads from the ISS to MSG and file uploads from MSG to the ISS are not described in this document, but can be found in Appendix B of [AD8].

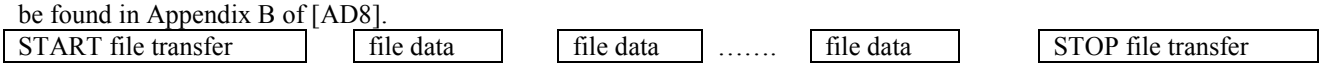

Figure 10: File transfer sequence

The first message indicates the source starts to transfer a file (Table 56) and after this message the transfer of the actual file takes place in messages with blocks of file data (Table 57). When the last block is sent from the source, a File Transfer End message (Table 58) is sent from the source of the file data.
In case of an error during transmission of a file, the procedure will have to be repeated.

Title : Start File Transfer message Direction: MLC <-> (WV1/ WV2), (WV1/ WV2)<-> RC or RC <-> MLC Protocol: EDLF (WV), MIL-bus (MLC) Frequency: Asynchronous				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
1	Destination	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
2	Class	1	mc_FILE	
3	Type	1	mat_FILE_START	
4	Length	2	4+length of filename including terminating zero	Number of bytes following this field. The length is an unsigned short
6	File Length	4	Total length of the file in bytes**	The length is an unsigned integer
10	Filename	<=64	Name of the file including terminating zero.	path name* Length of string including terminating NULL must be an even number of bytes

Table 56 Start file transfer command from WV to RC

*When the transfer takes place between the WV or MLC and the RC, the Filename must be the complete path including drive letter/device name of the RAM drive, directories and file name. When direct file transfer takes place between MLC and experiment, the filename parameter is not checked/used by the ASW.

**Files transferred to the RC are stored on a RAM drive. File size is limited to the size of the RAM drive when transferring a file to the RC over route B or C. Refer to Table 44 (page 54) for details regarding creation and removal of a RAM drive on the RC. Maximum file size when transferring between MLC and an experiment is not limited by the MSG DHS.

Title : File Data Blocks Direction: MLC <-> (WV1/ WV2), (WV1/ WV2)<-> RC or RC <-> MLC Protocol: EDLF (WV), MIL-bus (MLC) Frequency: 0-3 Hz				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
1	Destination	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
2	Class	1	mc_FILE	
3	Type	1	mat_FILE_DATA	
4	Length	2	3+length of the data block	The length is an unsigned short
6	Data	<=245		Length applies to size of unstuffed Data block (EDLF).
8+data	Sequence Counter	2	0x0000..0xFFFF	block counter
10+data	Checksum	1		The checksum is an unsigned short calculated over unstuffed data. It is computed over all bytes in the data block by an unsigned addition of all bytes without carry.

Table 57: Format of the file transfer data blocks

Title : Stop File Transfer message Direction: MLC <-> (WV1/ WV2), (WV1/ WV2)<-> RC or RC <-> MLC Protocol: EDLF (WV), MIL-bus (MLC) Frequency: Asynchronous				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	Source	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
1	Destination	1	ma_WV1, ma_WV2, ma_MLC or ma_SPLC	
2	Class	1	mc_FILE	
3	Type	1	mat_FILE_STOP	
4	Length	2	0x0000	no additional parameters

Table 58: Stop file transfer message from WV to RC

3.5 Protocol Descriptions

3.5.1 RS422 Protocols

Electrical Industry Standard RS422 uses a UART to establish a serial link between two users. The protocol used is partly fixed by the hardware. The configurable parameters of the interface, such as line speed and line settings (databits, start/stop bits and parity) can be set in device drivers.

RS422 can only be used as a point-to-point communication link.

Different protocols are used to ensure safe data traffic over the RS422 serial lines within the MSG Data Handling System. These protocols all contain a means to perform error checking on the data to be sent and received over the link.

I/F	Description	Used Protocol
1	Direct Experiment interface to WV 1	EDLF
2	CMP Experiment Control Board I/F	Proprietary
3	Video Interface	EDLF
4	CMP Housekeeping data interface	EDLF
5	Direct Experiment interface to WV 2	EDLF
9	Test Interface	TTY to VxWorks kernel

Table 59: RS422 Protocol Usage.

The transmission over the RS422 link is byte oriented, where the least significant bit will be transferred first (as opposed to the MIL-bus, where the MSB is transmitted first).
Communication settings are fixed and interface dependant.
A single byte will be transferred as a serial bit-stream of 10 bits

3.5.1.1 ESTEC Data Link Format Description (Protocol for I/F 1,3,4,5)

All data across these interfaces will be sent in packets. These packets will contain header information and the byte stuffing and checksum for that packet. Reception of a packet is considered successful if the checksum is correct and the "unstuffed" packet contains the correct header information. Stuffing is performed on certain predefined characters.

All predefined character codes are from the ASCII character and listed in Table 61 below.

In Binary Mode[4], full 8-bit data is allowed. Packets are formatted as follows:

Field	Size (octets)	Type	Meaning	Value
Start Code	1	ASCII	Start of Packet	STX
ID	2	ASCII	Byte Ordering; Intel / Motorola	II/MM
Data Length	2	BINARY	Number of data Octets	0..65535
Data	Variable	BINARY	-	0..255
Checksum	1	BINARY	Checksum	0..255
Stop Code	1	ASCII	End of Packet	ETX

Table 60: EDLF Packet Format.

The checksum is calculated from the ID, data length, and all data octets. The algorithm used is an 8-bit addition of all the octets without carry. If the packet was transmitted correctly, all the octets including the checksum octet must add up to zero.
Byte stuffing is performed on all of the fields from the Data Length field to the Checksum field inclusive. Occurrences of special characters are substituted as follows:

Data		Substitution		Data description
STX	0x02	DLE 'S'	0x10, 0x53	Start of Transmission
ETX	0x03	DLE 'E'	0x10, 0x45	End of Transmission
DLE	0x10	DLE 'D'	0x10, 0x44	Data Link Escape
CR	0x0D	DLE 'R'	0x10, 0x52	Carriage Return
LF	0x0A	DLE 'L'	0x10, 0x4C	Linefeed
II	0x49, 0x49	NA	NA	ID field value for Intel architecture
MM	0x4D, 0x4D	NA	NA	ID field value for Motorola architecture

Table 61: Character Substitution (EDLF).

The packet length field and checksum field must be calculated without byte stuffing. Byte stuffing is performed immediately before sending, and “unstuffing” immediately after reception.

All messages defined in this document are defined in the unstuffed format, which means that the actual amount of data is always at least 7 bytes more than the message itself, but often considerably more. It is the responsibility of the sender of data over an RS422 interface using EDLF to take this into account and prevent that an attempt is made to transmit more data over the interface than the hardware limitations allow, or else data is lost..
Regardless of the contents of the ID field, all data is transmitted in Big Endian format by the RC using EDLF as specified in §1.4.3. The data received by the RC is expected to be in Big Endian as well.

[4] There is also an ASCII mode of the EDLF protocol, but this mode is not used by the MSG DHS.

3.5.2 MIL-STD-1553B Protocol

Communication within the MSG rack and between the Rack Controller (RC) and its outside world takes place via a time-multiplexed, serial databus according to the MIL-STD-1553B military Standard. The MIL-STD-1553 is based on the command-response or master-slave principle where the (unique) Bus Controller (BC) is the bus master and (multiple) Remote Terminals (RT) are acting as slaves on the bus.

Internal communication between the RC and the RPDA/AAA and the MLC takes place via the internal MIL-bus where the Rack Controller acts as BC. RPDA/AAA and MLC are acting as RTs to the bus. The protocol described in this document is super-imposed on the MIL-STD-1553B standard [AD9].

External communication between the RC and Ground, MLC or Station itself takes place via the external MIL-bus to the Station 1553 data network. In this configuration the RC acts as a RT to the Station MDM. The details regarding the SPT protocol used on this connection can be found in [AD5].

Appendix A: SB Health & Status

The format for the Core Facility Health and status data packet will be the following:

Filterbank L								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
0	2	Differential Pressure (RF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb1Pressure1
2	2	Differential Pressure (FF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb1Pressure2
4	2	Gas (FF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb1Gas1
6	2	Gas (RF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb1Gas2
8	2	Humidity (T-corrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb1HumidityTsens
10	2	Humidity (uncorrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb1Humidity
12	2	Gas (FF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb1Gas3
14	2	Gas (RF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb1Gas4
16	1	Discrete						
		dP (FF) < 1 mb OR dP (FF) > 10 mb (bit 7, LSB)	0	false	1	true		Fb1Pressure1Lim
		dP (RF) < 1 mb OR dP (RF) > 10 mb	0	false	1	true		Fb1Pressure2Lim
		G (FF) (T/H-corrected) > 1000 ppm	0	false	1	true		Fb1Gas1Lim
		G (RF) (T/H-corrected) > 1000 ppm	0	false	1	true		Fb1Gas2Lim
		Hum (T-corrected) > 70%	0	false	1	true		Fb1HumidityLim

Filterbank C								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
17	1	<Not Used>, word alignment	0	---	---	---		.---
		Analog						
18	2							
20	2	Differential Pressure (RF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb2Pressure1
22	2	Differential Pressure (FF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb2Pressure2
24	2	Gas (FF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb2Gas1
26	2	Gas (RF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb2Gas2
28	2	Humidity (T-corrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb2HumidityTsens
30	2	Humidity (uncorrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb2Humidity
32	2	Gas (FF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb2Gas3
		Gas (RF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb2Gas4
34	1							
		Discrete						
		dP (FF) < 1 mb OR dP (FF) > 10 mb (bit 7, LSB)	0	false	1	true		Fb2Pressure1Lim
		dP (RF) < 1 mb OR dP (RF) > 10 mb	0	false	1	true		Fb2Pressure2Lim
		G (FF) > 1000 ppm	0	false	1	true		Fb2Gas1Lim
		G (RF) > 1000 ppm	0	false	1	true		Fb2Gas2Lim
		Hum (T-corrected) > 70%	0	false	1	true		Fb2HumidityLim
35	1	<Not Used>, word alignment	0	--	--	--		--

Filterbank R								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
36	2	Differential Pressure (RF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb3Pressure1
38	2	Differential Pressure (FF)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	Fb3Pressure2
40	2	Gas (FF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb3Gas1
42	2	Gas (RF) (T/H-corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb3Gas2
44	2	Humidity (T-corrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb3HumidityTsens
46	2	Humidity (uncorrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	Fb3Humidity
48	2	Gas (FF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb3Gas3
50	2	Gas (RF) (uncorrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	Fb3Gas4
52	1	Discrete						
		dP (FF) < 1 mb OR dP (FF) > 10 mb (bit 7, LSB)	0	False	1	True		Fb3Pressure1Lim
		dP (RF) < 1 mb OR dP (RF) > 10 mb	0	False	1	True		Fb3Pressure2Lim
		G (FF) > 1000 ppm	0	False	1	True		Fb3Gas1Lim
		G (RF) > 1000 ppm	0	False	1	True		Fb3Gas2Lim
		Hum (T-corrected) > 70%	0	False	1	True		Fb3HumidityLim
53	1	<Not Used>, word alignment	0	--	--	--		--

Work Volume								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
54	2	Differential Pressure (1)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	WvPressure1
56	2	Air Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	WvAirTemp
58	2	E-box Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	WvEBTemp
60	2	Humidity (T-corrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	WvHumidity
62	2	Differential Pressure (2)	7FF0 [0V]	0	FFF0 [+10V]	20	mb	WvPressure2
64	1	Discrete						
		dP < 1.3 mb (bit 7,LSB)	0	False	1	True		WvPressureLim
		Tair > 49°C	0	False	1	True		WvAirTempLim
		Backup Pressure sensor selected	0	Sensor 1	1	Sensor 2		WvBPressureSel
		Humidity (T-corrected) > 70%	0	False	1	True		WvHumidityLim
		Door L1 open	0	Closed	1	Open		WvDoorL1Open
		Door L2 open	0	Closed	1	Open		WvDoorL2Open
		Door R1 open	0	Closed	1	Open		WvDoorR1Open
		Door R2 open	0	Closed	1	Open		WvDoorR2Open
65	1	<Not Used>, word alignment	0	--	--	--		--

Airlock								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
66	2	dP Filter	7FF0 [0V]	0	FFF0 [+10V]	20	mb	AlPressure
68	2	Ambient Gas (T/H corrected)	7FF0 [0V]	250	FFF0 [+10V]	3000	ppm	AmbGas
70	2	Ambient Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	AmbTemp
72	2	Ambient Humidity (T-corrected)	7FF0 [0V]	0	FFF0 [+10V]	100	%RH	AmbHumidity
74	2	Reference Voltage (+5V)	7FF0 [0V]	0	FFF0 [+10V]	10	V	WlVref
76	2	Airlock Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	AlArlTemp
78	1	Discrete						
		dP < 1 mb OR dP > 10 mb (bit 7,LSB)	0	False	1	True		AlPressureLim
		Front door open	0	Closed	1	Open		AlFrontDoorOpen
		Top lid open	0	Closed	1	Open		AlTopLidOpen
		Illumination on	0	Off	1	On		AlIllOn
		Interlock Override enabled	0	Disabled	1	Enabled		AlILOvrdEnable

Fan Controller								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
79	1	Discrete						
		(One or more of the) Fans on (bit 7, LSB)	0	All off	1	L,C or R on		FanOn
		(One or more of the) Doors open	0	All closed	1	L or R open		DoorsOpen
		<Reserved>	---	---	---	---		---
		Overheat Detection 1	0	T < ± 70°C	1	T > ± 70°C		OHD1
		Overheat Detection 2	0	T < ± 70°C	1	T > ± 70°C		OHD2
		Overheat Detection 3	0	T < ± 70°C	1	T > ± 70°C		OHD3
		Overheat Detection 4	0	T < ± 70°C	1	T > ± 70°C		OHD4

Coldplate								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
80	2	Coldplate Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	CpTemperature
82	2	MTL in Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	MTLTempIn
84	2	MTL out Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	MTLTempOut
86	2	DC/DC Box Temperature	7FF0 [0V]	0	FFF0 [+10V]	100	°C	DCBoxTemp
88	1	Discrete						
		T coldplate > 49°C (bit 7, LSB)	0	False	1	True		CpTemperatureLim
		T MTL out > 28°C	0	False	1	True		MTLTemperatureLim
		Sealed Mode	0	False	1	True		SealedMode
		Open Mode	0	False	1	True		OpenMode
		Donning Mode	0	False	1	True		DonningMode
		Normal Mode	0	False	1	True		NormalMode
		Manual Mode	0	False	1	True		ManualMode

Process Control Valve								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
89	1	Discrete						
		Donning on (bit 7, LSB)	0	False	1	True		PcvDonning
		PCV Limit Switch "OPEN"	0	False	1	True		PcvLsOpen
		PCV Limit Switch "CLOSED"	0	False	1	True		PcvLsClosed
		PCV Motor on	0	False	1	True		PcvMotorOn
		PCV Motor direction	0	CW	1	CCW		PcvMotorDir
		Normal Mode	0	False	1	True		PcvNormalMode
		Normal Mode Motor Standby	0	False	1	True		PcvNormalModeMS

WV Illumination								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
90	1	Discrete						
		Illumination unit R on (bit 7, LSB)	0	Off	1	On		WvIllR
		Illumination unit C on	0	Off	1	On		WvIllC
		Illumination unit L on	0	Off	1	On		WvIllL
		(One or more of the) Illumination units on	0	All off	1	R,C or L on		WvIllOn
		Remote Override Switch	0	off	1	off		RemOverride
91	1	<Not Used>, word alignment	0	--	--	--		--

Power Control Unit 1								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
92	2	CMP +5V	7FF0 [0V]	0	FFF0 [+10V]	+10	V	Power0
94	2	CMP +12V	7FF0 [0V]	0	FFF0 [+20V]	+20	V	Power1
96	2	CMP -12V	0 [-20V]	-20	7FF0 [0V]	0	V	Power2
98	2	ILL1 +28V	7FF0 [0V]	0	FFF0 [+30V]	+30	V	Power3
100	2	ILL2 +28V	7FF0 [0V]	0	FFF0 [+30V]	+30	V	Power4
102	2	AL +28V	7FF0 [0V]	0	FFF0 [+30V]	+30	V	Power5
104	2	ICP +12V	7FF0 [0V]	0	FFF0 [+20V]	+20	V	Power6
106	1	Discrete						
		Main on (bit 7, LSB)	0	Standby	1	On		PCMainOn
		<Not Used>	--	--	--	--		--
		Main +5V present	0	False	1	True		PCMain5V
		Inhibit +120V Experiment	0	Not present	1	Present		PC120Vinh
		Inhibit Experiment Power Outlet 1	0	Not present	1	Present		PCPOut1Inh
		Inhibit Experiment Power Outlet 2	0	Not present	1	Present		PCPout2Inh
		Inhibit ICP outlet	0	Not present	1	Present		PCICPInh
107	1	<Not Used>, word alignment	0	--	--	--		--

Power Control Unit 2								
Position	Length	Remarks	Min Value	Min. Repr.	Max. Value	Max. Repr.	Unit	ASW Identifier
		Analog						
108	2	Experiment outlet 1 +5V	7FF0 [0V]	0	FFF0 [+10V]	+10	V	ExpPwr0
110	2	Experiment outlet 1 +12V	7FF0 [0V]	0	FFF0 [+20V]	+20	V	ExpPwr1
112	2	Experiment outlet 1 -12V	0 [-20V]	-20	7FF0 [0V]	0	V	ExpPwr2
114	2	Experiment outlet 1 +28V	7FF0 [0V]	0	FFF0 [+30V]	+30	V	ExpPwr3
116	2	Experiment outlet 2 +5V	7FF0 [0V]	0	FFF0 [+10V]	+10	V	ExpPwr4
118	2	Experiment outlet 2 +12V	7FF0 [0V]	0	FFF0 [+20V]	+20	V	ExpPwr5
120	2	Experiment outlet 2 -12V	0 [-20V]	-20	7FF0 [0V]	0	V	ExpPwr6
122	2	Experiment outlet 2 +28V	7FF0 [0V]	0	FFF0 [+30V]	+30	V	ExpPwr7
124	1	Discrete						
		Experiment outlet 1 +5V (bit 7, LSB)	0	Off	1	On		ExpPwrOn0
		Experiment outlet 1 ±12V	0	Off	1	On		ExpPwrOn1
		Experiment outlet 1 +28V	0	Off	1	On		ExpPwrOn2
		Experiment +120V on	0	Off	1	On		ExpPwrOn3
		Experiment outlet 2 +5V	0	Off	1	On		ExpPwrOn4
		Experiment outlet 2 ±12V	0	Off	1	On		ExpPwrOn5
		Experiment outlet 2 +28V	0	Off	1	On		ExpPwrOn6
		ICP +12V on	0	Off	1	On		ExpPwrOn7
125	1	<Not Used>, word alignment	0	--	--	--		--

Appendix B: Constant Assignments

The following IDs have been identified in the file msghdr.h:

```
/*  File Name        : msghdr.h                                        */
/*  File description : This file contains the definitions for the */
/*                     MSG Header Format and the MSG command codes*/
/*  Revision         : 1.1                                             */
/*  Date             : 25-02-2000                                      */
/*  Project name     : MSG                                             */
/*  Author           : Erwin Schreutelkamp                             */
/*  Company          : Origin Netherlands b.v                          */
/*                                                                     */
/*  File History:                                                      */
/*   Date       Person  Comment                                        */
/*   11-08-1999 ErSc    Initial version                               */
/*   25-02-2000 RoTr    Video IDs added                               */
/*   21-03-2000 ErLe    changed ma_PCS to ma_MLC, added ma_MLC_HS */
/*   31-03-2000 ErLe    changed ma_AVECS to ma_SPLC                   */
/*                       added ma_ASL, ma_ASL_LOG and ma_ASW_LOG   */
/*   25-04-2000 ErLe    added 4 additional RPDA commands              */
/*   25-04-2000 ErLe    updated to reflect BSW private headers,   */
/*                       influences addresses, types and classes!!!*/
/*                       removed references to ASL                     */
/*   28-06-2000 ErLe    Added file upload/download commands and   */
/*                       route report                                  */
/*   16-07-2000 ErLe    Added RDPDA Dig. Test IN commands             */
/*   28-07-2000 ErLe    Added cmd_STORE_USER_LIM_SET and              */
/*                       cmd_REMOVE_USER_LIM_SET commands, removed */
/*                       obsolete SB data flow control commands    */


/* INFO: CHANGES TO THIS FILE IMPLICITLY REQUIRES AN UPDATE */
/*       OF THE ASW MODULE Logging.c                           */

#ifndef MSGHDR_INCLUDED
#define MSGHDR_INCLUDED

#ifdef AVBSW_MSG


/* MSG Address Constants */
enum msg_addr_e {
  ma_UNSPECIFIED   = 0,
  ma_SSL           = 1, /* used for sending commands directly to the SSL */

  ma_address_base   = 127, /* 0 to 127 reserved for use by SSL */
  ma_SPLC          = 128, /* was originally ma_AVECS, meaning unchanged*/
  ma_ISSA_LOWRATE  = 129,
  ma_ISSA_MRDL     = 130,
  ma_MLC           = 131,   /* was originally ma_PCS, meaning unchanged*/
  ma_RPDA          = 132,
  ma_AAA           = 133,
  ma_EXP_1         = 134,
  ma_EXP_2         = 135,
```

```
  ma_EXP_AD_CONV   = 136,
  ma_CORE_SC       = 137,
  ma_RACK_SC       = 138,
  ma_TEST          = 139,
  ma_SIA           = 140,
  ma_ANALOG_IO     = 141,
  ma_RC            = 142,
  ma_ASW           = 143,
  ma_ISS_XBUS      = 144,
  ma_RPDA_AAA      = 145,
  ma_WV1           = 146,
  ma_WV1_HS        = 147,
  ma_WV1_LOG       = 148,
  ma_WV1_LRT       = 149,
  ma_WV2           = 150,
  ma_WV2_HS        = 151,
  ma_WV2_LOG       = 152,
  ma_WV2_LRT       = 153,
  ma_SB            = 154,
  ma_SB_HS         = 155,
  ma_SB_LOG        = 156,
  ma_SPARE_1       = 157,
  ma_ECB           = 158,
  ma_ECB_LRT       = 159,
  ma_ECB_LOG       = 160,
  ma_RPDA_ESEM     = 161,
  ma_RPDA_HS       = 162,
  ma_LOGGER        = 163,
  ma_VIDEO         = 164,
  ma_VIDEO_HS      = 165,
  ma_VIDEO_LOG     = 166,
  ma_STATUS_HS     = 167,
  ma_STATUS_ESEM   = 168,
  ma_SSL_LOG       = 170,
  ma_ASW_LOG       = 171,
  ma_MLC_HS        = 173,
  __ma_max__
} ;

typedef enum msg_addr_e msg_addr_e ;
typedef u_char msg_addr_t ;

/* MSG Class Constants */
enum msg_class_e {
  mc_CMD           = 128 /* setting the MSB of the class field to 1 indicates
                            message is a command, when set to 0 it is data */
  mc_CMD_AND_ACK   = 136 /* default: class indicates command and acknowledge
                            flags indicate a "command accept"/"command received"
                            message is required */

  mc_UNSPECIFIED   = 0,
  mc_HOUSEKEEPING  = 1,
  mc_TELEMETRY     = 2

/*classes 0 to 63 defined by /reserved for SSL*/
  mc_ACK_REC       = 64,
```

```
  mc_LOG            = 65,

  mc_SYSTEM         = 66,
  mc_STATUS         = 67,
  mc_FILE           = 68,
  __me_max__
/* MAY NOT EXCEED 127 (most significant bit indicates message is command or
data!) */
} ;

typedef enum msg_class_e msg_class_e ;
typedef u_char msg_class_t ;

/* MSG (for AVECS) type constants */
enum msg_splc_type_e {
  mat_UNSPECIFIED   = 0,
  mat_LOG           = 1,
  mat_TASK          = 2,
  mat_ROUTE         = 3,
  /*mat_FILE removed */
  mat_MONITOR       = 5,
  mat_VERIF         = 6,
  mat_TIME          = 7,
  mat_CNF_UPDATE    = 8,
  mat_HS            = 9,
  mat_CONFIG        = 10,
  mat_COMMAND       = 11,
  mat_LRT           = 12,
  mat_CF            = 13,
  mat_ESEM          = 14,
  mat_IF            = 15,
  mat_FILE_START    = 16,
  mat_FILE_DATA     = 17,
  mat_FILE_STOP     = 19,
  __mat_max__
} ;

typedef enum msg_splc_type_e msg_splc_type_e ;
typedef u_char msg_type_t ;

typedef struct _msghdr_t {
  msg_addr_t  Source ;
  msg_addr_t  Dest ;
  msg_class_t Class ;
  msg_type_t  Type ;
} msghdr_t, msghdr_ptr ;

/* NB - structure may be padded on some architectures */
#define MSGHDRSZ sizeof(msghdr_t)

/* MSG Command Id's */
enum _msg_command_id_e {

  __cmd_base__              = 0x1B,
  /* ECB Configuration & control commands */
  cmd_ENABLE_ECB_DATA       = 0x1C,
```

```
cmd_DISABLE_ECB_DATA     = 0x1D,
cmd_OUTPUT_BYTE          = 0x1E,
cmd_SELECT_CHAN          = 0x1F,

/* Core facility commands */
cmd_AL_ILLUMINATION      = 0x20,
cmd_FAN_SP_SPEED_NORMAL  = 0x21,
cmd_FAN_SP_SPEED_DONNING = 0x22,
cmd_PCV_DONNING          = 0x23,
cmd_PCV_SP_NEG_PRESS     = 0x24,
cmd_WV_ILLUMINATION      = 0x25,
cmd_WV_ILL_SP_INTENSITY  = 0x26,
cmd_EXP_1_PWR_0          = 0x27,
cmd_EXP_1_PWR_1          = 0x28,
cmd_EXP_1_PWR_2          = 0x29,
cmd_EXP_2_PWR_0          = 0x2A,
cmd_EXP_2_PWR_1          = 0x2B,
cmd_EXP_2_PWR_2          = 0x2C,
cmd_EXP_PWR_120          = 0x2D,
cmd_EXP_PWR_ICP          = 0x2E,

/* SB Data flow control commands - removed (no longer needed) */
/* store/remove limit settings */
cmd_STORE_USER_LIM_SET   = 0x3f
cmd_REMOVE_USER_LIM_SET  = 0x30

/* RPDA/AAA commands */
cmd_ESEM3_O1_FAN_MOTORS     = 0x31,
cmd_ESEM3_O2_EXP_POWER_120V = 0x32, /*25/04/00 changed from cmd_EXP_POWER*/
cmd_ESEM4A_O1_LAPTOP        = 0x33,
cmd_AAA_SPEED               = 0x34,
/*--additional RPDA commands at the end of the list--*/

/* ASW Configuration update commands */
cmd_ASW_ADD_ROUTE        = 0x35,
cmd_ASW_DELETE_ROUTE     = 0x36,

/* Video commands */
cmd_SYSTEM_TIME          = 0x37,
cmd_POWER_CONTROL        = 0x38,
cmd_VIDEO_ROUTING        = 0x39,
cmd_VCR_STOP             = 0x3A,
cmd_VCR_PAUSE            = 0x3B,
cmd_VCR_PLAY             = 0x3C,
cmd_VCR_RECORD           = 0x3D,
cmd_VCR_TIMELAPSE        = 0x3E,
cmd_VCR_FFWD             = 0x3F,
cmd_VCR_REW              = 0x40,
cmd_CAM_TIME_OVERLAY     = 0x41,
cmd_CAM_DIRECT           = 0x42,


/*ADDITIONAL RPDA commands*/
cmd_ESEM3_O3_CMP_AND_EXP_12V_5V   = 0x44,
cmd_ESEM3_O4_AAA_AND_ASDA         = 0x45,
cmd_ESEM4B_O1_ILLUM_SPLC_AIRLOCK  = 0x46,
```

```
  cmd_ESEM4B_O2_EXP_POWER_28V       = 0x48,
  cmd_ESEM4A_O2_VIDEO               = 0x49,
  cmd_ESEM4A_O2_VIDEO               = 0x50
  cmd_ESEM1_DIG_TEST_IN             = 0x51
  cmd_ESEM3_DIG_TEST_IN             = 0x52
  cmd_ESEM4A_DIG_TEST_IN            = 0x53
  cmd_ESEM4B_DIG_TEST_IN            = 0x54


  /* File Transfer Commands (to and from RC) */
  cmd_SW_FILE_UPLOAD         = 0x60,
  cmd_SW_FILE_FLASH_STORE  = 0x61,
  cmd_FILE_UPLOAD          = 0x62,
  cmd_ROUTE_REPORT         = 0x63,


  /* WV1 Commands */
  /* Out of Scope -> experiment specific */

  /* WV2 Commands */
  /* Out of Scope -> experiment specific */




  __cmd_max__
} ;

typedef enum _msg_command_id_e msg_command_id_e ;

#endif /* AVBSW_MSG */

#endif /* MSGHDR_INCLUDED */

/* END OF FILE msghdr.h */
```

Appendix C: Video Interface details

The following information is applicable to the Video Interface and supplements §3.1.8 (page 28).

Video Health & Status Data Packet				
Offset (bytes)	Field Name	Length (bytes)	Value	Remarks
0	System Time: Hours	1	BCD00-BCD23	BCD Notation
1	System Time: Minutes	1	BCD00-BCD59	BCD Notation
2	System Time: Seconds	1	BCD00-BCD59	BCD Notation
3	Power Control 1	1	See Table 63	
4	Power Control 2	1	”	
5	Video source selection for Monitor 1	1	See Table 64	
6	Video source selection for Monitor 2	1	”	
7	Video source selection for output to downlink	1	”	
8	Status Recorder 1	6	SeeTable 65	
14	Status Recorder 2	6	”	
20	Status Recorder 3	6	”	
26	Status Recorder 4	6	”	
32	Status Camera 1	1	0=Error, 1=OK	
33	Status Camera 2	1	”	
34	Status Camera 3	1	”	
35	Status Camera 4	1	”	
36	Camera Response	34	See Table 66	

Table 62: Video Housekeeping Data Message

field	Bit	Description	Value	Remarks
Power Control 1	7 (LSB)	Main Power	0: Standby 1: Power On	
	6	Power Monitor 1	0: OFF 1: ON	
	5	Power Monitor 2	0: OFF 1: ON	
	4	Microphone	0: OFF 1: ON	
	3	OHD level 1	0: ERROR 1:OK	
	2	Not Used		
	1	Not Used		
	1 (MSB)	Not Used		
Power Control 2	7(LSB)	Power Camera 1	0: OFF 1: ON	
	6	Power Camera 2	0: OFF 1: ON	
	5	Power Camera 3	0: OFF 1: ON	
	4	Power Camera 4	0: OFF 1: ON	
	3	Power Recorder 1	0: OFF 1: ON	
	2	Power Recorder 2	0: OFF 1: ON	
	1	Power Recorder 3	0: OFF 1: ON	
	0 (MSB)	Power Recorder 4	0: OFF 1: ON	

Table 63: Power Control block definition

Value	Description
0	Camera 1
1	Camera 2
2	Camera 3
3	Camera 4
4	VCR 1
5	VCR 2
6	VCR 3
7	VCR 4

Table 64: Routing ID's

Offset	Bit	Description	Value	Remarks
0	7 (LSB)	Recorder OK	0: Error 1: OK	
	6	Tape inserted	0: no tape 1: tape present	
	5	Not used		
	4	Not Used		
	0 - 3	Current Operation	0: Stop 1: Still 2: Pause 3: Play 4: Record 5: Record TL 6: FFWD 7: REW 8: Shuttle Fwd 9: Shuttle Rew	Pause during Playback Pause during record
1	all	TimeCode Hours	BCD00 – BCD23	BCD notation
2	all	TimeCode Minutes	BCD00 – BCD59	BCD Notation
3	all	TimeCode Seconds	BCD00 – BCD59	BCD Notation
4	all	Timelapse recording period	5 – 255: 0.5 – 25.5 sec	
5	all	Timelapse pause period	5 – 255: 5 – 255 sec	

Table 65: Recorder Status block definition

Offset	Description	Value	Remarks
0	Camera	0: Camera 1 1: Camera 2 2: Camera 3 3: Camera 4	
1	Data Length	0: No data >0: length of valid data	
2-33	Response Data from camera, 32 bytes	Binary data	contents depending on command sent to camera

Table 66: Camera Response block definition

Video Commands

In following table the commands supported by the Video Assembly are listed.

Command	CMD_ID See Appendix B for values	Description	Parameter bytes
System Time	cmd_SYSTEM_TIME	Sets system time for the Video Assembly. This time is used for time display on the camera(s)	4 (Table 68)
Power Control	cmd_POWER_CONTROL	Switches power on/off	2 (Table 69)
Video Routing	cmd_VIDEO_ROUTING	Selects input source for monitors and downlink	2 (Table 70)
VCR Stop	cmd_VCR_STOP	Sends Stop command to recorder (release tape)	2 (Table 71)
VCR Pause	cmd_VCR_PAUSE	Sends Pause command to recorder (hold tape)	2 (Table 71)
VCR Play	cmd_VCR_PLAY	Sends Start command to recorder	2 (Table 71)
VCR Record	cmd_VCR_RECORD	Sends Record command to recorder (continuous recording)	2 (Table 71)
VCR Timelapse	cmd_VCR_TIMELAPSE	Starts timelapse recording. The Video Assembly S/W controls the recording	4 (Table 72)
VCR Forward	cmd_VCR_FFWD	Sends Forward command to recorder	2 (Table 71)
VCR Rewind	cmd_VCR_REW	Sends Rewind command to recorder	2 (Table 71)
Cam Time Overlay	cmd_CAM_TIME_ OVERLAY	Enable/Disables automatic overlay of time, shows system time on camera	2 (Table 79)
Cam direct command	cmd_CAM_DIRECT	Provides a direct command interface to the camera. The data part of the command will be sent to the camera literally	32 (Table 73)

Table 67: Video Commands

Note: The VD will check if the command was accepted. The VD does not check the result of the command. This applies for all VCR commands. The result can only be checked by viewing the status on the user interface or in the (optional) housekeeping data. (Example: When there is no tape in the recorder and the play command is sent, it will not start playing)

System Time Parameters

The System Time Command sets the system time of the VD to the time in this message. This system time is used for the automatic time overlay for the cameras. Normally this command will be sent once after the VD is switched on or when a new experiment starts. On startup the VCU will get the time from the on-board real time clock and use this time until the system time command is used.

System Time Parameters			
Offset	Description	Value	Remarks
0	Hours	BCD00-BCD23	BCD Notation
1	Minutes	BCD00-BCD59	BCD Notation
2	Seconds	BCD00-BCD59	BCD Notation
3	Not used		Word Alignment

Table 68: System Time parameters format

Power Control Parameters

The Power Control command switches all relays (cameras, recorders, monitor and main power) according to the state in this command.

Power Control Parameters				
Offset	Bit	Description	Value	Remarks
0	0 (LSB) 1	Main Power Power Monitor 1	0: Standby 1: On 0: Off 1: On	
1	7 (LSB) 6 5 4 3 2 1 0 (MSB)	Power Camera 1 Power Camera 2 Power Camera 3 Power Camera 4 Power Recorder 1 Power Recorder 2 Power Recorder 3 Power Recorder 4	0: Off 1: On 0: Off 1: On 0: Off 1: On 0: Off 1: On 0: Off 1: On 0: Off 1: On 0: Off 1: On 0: Off 1: On	

Table 69: Power Control command switches

Video Routing Parameters

The video routing command set the three multiplexers for the monitors and the downlink. Each multiplexer selects one of the 8 inputs (4 cameras, 4 recorders)

Video Routing Parameters			
Offset	Description	Value	Remarks
0	Video source selection for output to Monitor 1	See Table 64	
1	Video source selection for output to Monitor 2	See Table 64	
2	Video source selection for output to DownLink	See Table 64	
3	Not used		Word Alignment

Table 70: Video Routing parameters

VCR action parameters

The VCR Stop, VCR Pause, VCR Play, VCR Record VCR Forward and VCR Rewind have the same parameter options. The functions speak for itself.

VCR Stop Parameters VCR Pause Parameters VCR Play Parameters VCR Record Parameters VCR Forward Parameters VCR Rewind Parameters			
Offset	Description	Value	Remarks
0	Recorder selection	0: VCR 1 1: VCR 2 2: VCR 3 3: VCR 4	
1	Not used		Word Alignment

Table 71: Video action parameters

VCR Timelapse Parameters

The Timelapse Record Command is the only recorder command that is not available in the recorder itself. It is implemented in S/W. First a record command is sent, the VCR will start recording. Then the S/W will generate pause commands to stop and restart the recording. The delay between the pause commands is according to the recording and pause period in the Timelapse Record command.

VCR Timelapse Parameters			
Offset	Description	Value	Remarks
0	Recorder selection	0: VCR 1 1: VCR 2 2: VCR 3 3: VCR 4	
1	Recording Period in 0.1 seconds	5 – 255	Minimum recording period 0.5 seconds
2	Pause period in seconds	5 – 255	Minimum pause period 5 seconds
1	Not used		Word Alignment

Table 72: VCR Timelapse parameters

CAM Direct Parameters

The Cam Direct Command provides a direct interface to the cameras. The data in the Camera command data part is sent to the camera directly (via RS232 interface). The VD S/W does not change or check the data.
The response from the camera on this command is stored in the housekeeping data. The housekeeping data can only buffer one response. If another response is received before the housekeeping data is transmitted, the response is lost.

CAM Direct Parameters			
Offset	Description	Value	Remarks
0	Camera selection	0: CAM 1 1: CAM 2 2: CAM 3 3: CAM 4	
1	Data Length	1 - 30	Indicates length of valid data bytes in camera command data
2 – 31	Camera command data	binary	30 byte command data block

Table 73: CAM Direct Parameter

Figure 11 shows how CAM Direct commands are handled by the VCU.

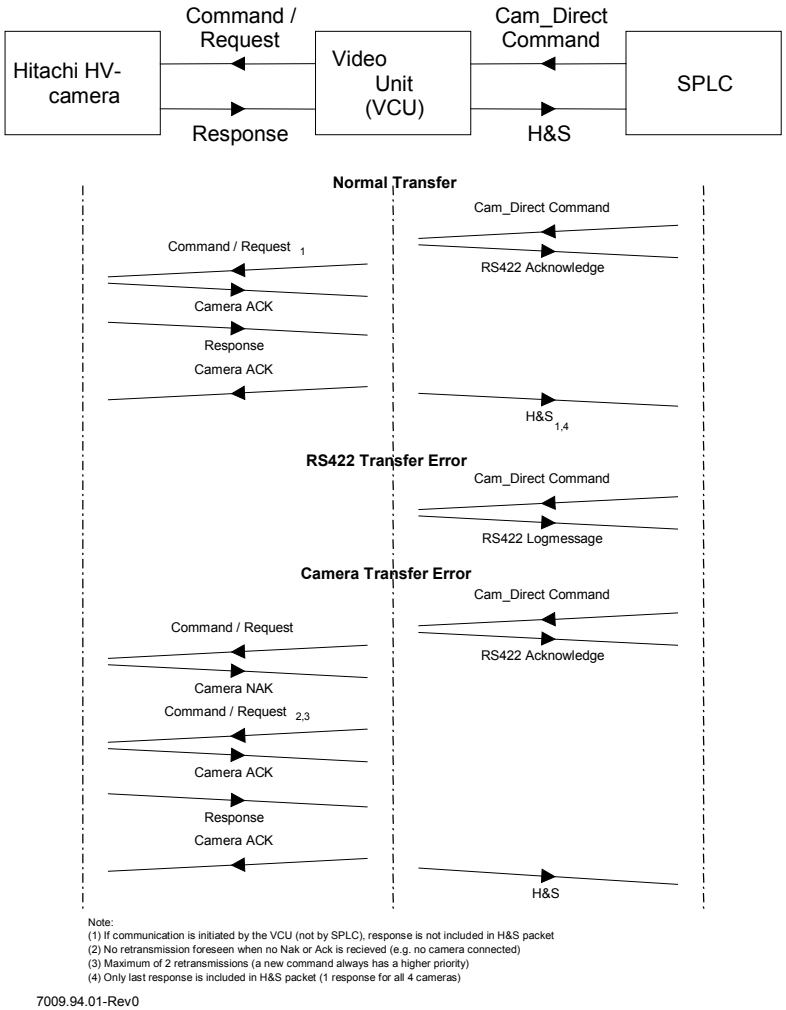

Figure 11: Camera Communication

The Hitachi HV-C20 communications protocol comprises 5 types of messages.

- Commands (VCU → camera)
- Requests (VCU → camera)
- Responses (camera → VCU)
- ACK (camera ←→ CVU)
- NAK (camera ←→ CVU)

The composition for the Command, Request and Response message is shown in Table 74:

Field	Size (bytes)	Type	Meaning	Value
Start Code	1	ASCII	STX, Start of Packet	0x02
Data Length	1	BINARY	Number of data bytes (0 indicates a length of 256)	0..255
Data	Variable (1..256)	BINARY	-	0..255
Checksum	2	BINARY	Checksum	0..65535

Table 74: HV-C20 Message Composition.

The checksum is calculated on all bytes between the Start Code and the checksum. The checksum is the complement of the (16-bit) sum of all these bytes. The least significant byte of the checksum is sent first, the most significant byte follows.

An Example of a message: the BAR/CAM:BAR command:
STX : 0x02
Data Length : 0x04
DT1 – DT4 : 0x20 0x08 0x01 0xFE
SUM : 0x04 + 0x20 + 0x08 + 0x01 + 0xFE = 0x01 0x2B
complement : 0xFE 0xD4

Message : 0x02 0x04 0x20 0x08 0x01 0xFE 0xD4 0xFE

The ACK (0x06) and NAK (0x15) messages are one-character messages. These messages confirm a correct reception (ACK) or indicate a transfer error (NAK).

For the VD the following commands are valid:
- On/Off Control Commands
- Analog Control Commands
- Auto Function Control commands
- Character String Display Control commands

ON/OFF control commands:

	Command	Val	Request	Val	Response	Val
Start Code	STX	0x02	STX	0x02	STX	0x02
n	4		2		3	
(DT1)	Control	0x20 or 0x28 see table	Control	0x23 or 0x2B see table	Control	0x22 or 0x2A see table
(DT2)	Mode	0x00 – 0x3F see table	Mode	0x00 – 0x3F see table	Mode	0x00 – 0x3F see table
(DT3)	Data	see table	-	-	Data	see table
(DT4)	Mask	see table	-	-	-	-

Table 75: On/Off Control Commands

Appendix C: Video Interface details

The following tables describe the available functions and the meaning of the data. These tables have been copied literally from the Hitachi Command List for HV-C20 Remote Control.

(DT1)	(DT2)	(DT3)			(DT4)
CTL	MODE	Bit	Item		MASK
0x20 0x23 0x22	0x00	0	PRESET WHITE BAL		0
		1			1
		2			1
		3			1
		4			1
		5			1
		6			1
		7			1
	0x01	0			1
		1			1
		2			1
		3			1
		4			1
		5	GAIN	0	0
		6		1	0
		7			1
	0x02	0			1
		1	GAMMA		S
		2	KNEE		S
		3	WHITE CLIP		S
		4			1
		5			1
		6			1
		7			1
	0x04	0	IRIS	0	S
		1		1	S
		2	WHITE BAL	0	S
		3		1	S
		4	AGC	0	S
		5		1	S
		6			1
		7			1

PRESET WHITE BAL

3200K	5600K	(DT4)
0	1	0xFE

GAIN

	NORM	HIGH	MAX	-	(DT4)
0	0	1	0	1	0x9F
1	0	0	1	1	

GAMMA

ON	OFF	(DT4)
0	1	0xFD

KNEE

ON	OFF	(DT4)
0	1	0xFB

WHITE CLIP

ON	OFF	(DT4)
0	1	0xF7

IRIS

	-	MANU	AUTO	-	(DT4)
0	0	1	0	1	0xFC
1	0	0	1	1	

WHITE BAL

	PRESET	MEM	AUTO	-	(DT4)
0	0	1	0	1	0xF3
1	0	0	1	1	

AGC

	OFF	VAR	ON	-	(DT4)
0	0	1	0	1	0xCF
1	0	0	1	1	

(DT1)	(DT2)	(DT3)			(DT4)
CTL	MODE	Bit	Item		MASK
0x20 0x23 0x22	0x05	0	SHUTTER	0	S
		1		1	S
		2		2	S
		3		3	S
		4		4	S
		5		5	S
		6	SHUTTER EXT TRIG	0	S
		7	(HV-C20 only)	1	S
	0x07	0			1
		1			1
		2	DTL	0	0
		3		1	0
		4			1
		5			1
		6			1
		7			1
	0x08	0	BAR/CAM		S
		1	CONTRAST		S
		2			1
		3			1
		4			1

		5		1
		6		1
		7		1
	0x11	0		1
		1		1
		2		1
		3		1
		4		1
		5	G ON SYNC (HV-C20 only)	S
		6		1
		7	GL IN IMP	S

SHUTTER

	OFF	1/ 100	1/ 250	1/ 500	1/ 1000	1/ 2000	1/ 4000	1/ 10000	Var.	AES	EXT	(DT4)
0	0	1	1	1	1	1	1	1	1	1	1	0xCO
1	0	0	0	0	0	0	0	0	1	0	1	
2	0	0	0	0	0	0	0	0	0	1	1	
3	1	1	0	1	0	1	0	1	1	1	1	
4	0	0	1	1	0	0	1	1	1	1	1	
5	0	0	0	0	1	1	1	1	1	1	1	

SHUTTER EXT TRIG

	1 TRIG	2 TRIG	FIX TRIG	EXT TRIG	(DT4)
0	0	1	0	1	0x3F
1	0	0	1	1	

DTL

	OFF	LOW	NORM	HIGH	(DT4)
0	0	1	0	1	0xF3
1	0	0	1	1	

BAR/CAM

CAM	BAR	(DT4)
0	1	0xFE

CONTRAST

OFF	ON	(DT4)
0	1	0xFD

G ON SYSNC

OFF	ON	(DT4)
0	1	0xDF

GL IN IMP

75ohm	HIGH	(DT4)
0	1	0x7F

(DT1)	(DT2)	(DT3)			(DT4)
CTL	MODE	Bit	Item		MASK
0x28 0x2B 0x2A	0x00	0	ID	0	S
		1		1	S
		2	TITLE	0	S
		3		1	S
		4	OPEN LIMIT		S
		5	CLOSE LIMIT		S
		6	IRIS GATE DSP		S
		7	IRIS GATE CONT		S
	0x01	0	LENS TYPE		S
		1			1
		2	SHAD MODE		S
		3			1
		4	FLD/FRM		S
		5	IRIS GATE PATTERN	0	S
		6		1	S
		7	CAM MODE		S
	0x04	0	IRIS GATE H POSI. 0x00 (LEFT)~ 0x0B (RIGHT)	0	0
		1		1	0
		2		2	0
		3		3	0
		4			1
		5			1
		6			1
		7			1
	0x05	0	IRIS GATE H POSI. 0x00 (UP)~ 0x06 (DOWN:NTSC) 0x08 (DOWN:PAL)	0	0
		1		1	0
		2		2	0
		3		3	0
		4			1
		5			1
		6			1
		7			1
	0x06	0	GAIN HIGH 0x01(+dB)~ 0x11(+17dB)	0	0
		1		1	0
		2		2	0
		3		3	0
		4		4	0
		5			1
		6			1
		7			1

ID

	OFF	TOP	BOTTOM	-	(DT4)
0	0	1	0	1	0xFC
1	0	0	1	1	

TITLE

	OFF	TOP	BOTTOM	-	(DT4)
0	0	1	0	1	0xF3
1	0	0	1	1	

OPEN LIMIT

OFF	ON	(DT4)
0	1	0xEf

CLOSE LIMIT

OFF	ON	(DT4)
0	1	0xDF

IRIS GATE DSP

OFF	ON	(DT4)
0	1	0xBF

IRIS GATE CONT

OFF	ON	(DT4)
0	1	0x7F

LENS TYPE

VIDEO	DC	(DT4)
0	1	0xFE

SHAD MODE

LUMI	COLOR	(DT4)
0	1	0xFB

FLD/FRM

FLD	FRM	(DT4)
0	1	0xEF

IRIS GATE PATTERN

	1	2	3	4(PAL only)	(DT4)
0	0	1	0	1	0x9F
1	0	0	1	1	

CAM MODE

MANU	AUTO	(DT4)
0	1	0x7F

(DT1)	(DT2)	(DT3)			(DT4)
CTL	MODE	Bit	Item		MASK
0x28 0x2B 0x2A	0x07	0	GAIN MAX 0x02(+2dB)~ 0x12(+18dB)	0	0
		1		1	0
		2		2	0
		3		3	0
		4		4	0
		5			1
		6			1
		7			1
	0x08	0	AGC LIMIT 0x06(+6dB)~ 0x12(+18dB)	0	0
		1		1	0
		2		2	0
		3		3	0
		4		4	0
		5			1
		6			1
		7			1
		0			1
		1			
		2			1
		3			1
		4			1
		5			1
		6			1
		7			1

Analog Control commands:

	Command	Val	Request	Val	Response	Val
Start Code	STX	0x02	STX	0x02	STX	0x02
n	3 or 4	0x03 or 0x04	2	0x02	3 or 4	0x03 or 0x04
(DT1)	Control	0x30	Control	0x33	Control	0x32
(DT2)	Mode	0x00 – 0xFF see table	Mode	0x00 – 0xFF see table	Mode	0x00 – 0xFF see table
(DT3)	Data	see table	-	-	Data	see table
(DT4)	Data	see table	-	-	Data	see table

Table 76: Analog Control Commands

The length of the command and response depend on the type of analog control. An 8-bit control uses 1 data byte (length 3), a 16-bit control uses 2 data bytes (length 4). When a 16-bit control is involved, DT3 represents the upper 8 bits, DT4 the lower part.

Item	(DT1) DTL	(DT2) MODE	(DT3)u (DT4)D DATA
R GAIN	0x30 0x33 0x32	0x18	0x80XX~0x00XX~0x7FXX (signed) -128 0 +127
B GAIN		0x1A	0x80XX~0x00XX~0x7FXX (signed)
R BLACK		0x21	0x80XX~0x00XX~0x7FXX (signed)
B BLACK		0x23	0x80XX~0x00XX~0x7FXX (signed)
AGC VAR		0x2A	+18dB +9dB 0dB 0x80XX~0x00XX~0x7FXX (signed)
MASTER BLACK		0x2B	0x80XX~0x00XX~0x7FXX (signed)
LENS REMOTE		0x2E	0x80XX~0x00XX~0x7FXX (signed) CLOSE OPEN
SC PHASE		0x33	(See below)
H.PHASE		0x34	0x80XX~0x00XX~0x7FXX (signed) -128 0 +127
SHUTTER Ver.		0x38	NTSC : FFE2(1/1)~0xFFFF(1/30) LONG EXPOSURE (STANDARD) 0xFF10(8.0)~0xFFFF(1/30) LONG EXPOSURE (HV-C20-S4) 0x0002(1/60.38)~0x0105(1/10168) LOCK SCAN PAL : 0xFFE7(1/1)~0xFFFF(1/25) LONG EXPOSURE (STANDARD) 0xFF38(8.0)~0xFFFF(1/25) LONG EXPOSURE (HV-C20-S4) 0x0002(1/50.31)~0x0137(1/10040) LOCK SCAN
OVER RIDE		0x39	0x80XX~0xC0XX~0x00XX~0x40XX~0x7FXX (signed) -1.0 -0.5 0 +0.5 +1.0
IRIS SPEED		0x3A	0x9XXX~0x0XXX~0x7XXX (signed) SLOW FAST
CLOSE LIMIT		0x3B	0x80XX~0x00XX~0x7FXX (signed) CLOSE OPEN
OPEN LIMIT		0x3C	0x3FXXh ~ 0x7FXXh CLOSE OPEN
R SHADING		0x8F	0x80XX~0x00XX~0x7FXX (signed)
G SHADING		0x90	0x80XX~0x00XX~0x7FXX (signed)
B SHADING		0x91	0x80XX~0x00XX~0x7FXX (signed)

SC PHASE		HV-C20 Ver 1.0		HV-C20 Ver 1.1	
SC COARSE	SC FINE	(DT3)	(DT4)	(DT3)	(DT4)
0°	-128	00 10 00 00	00 XX XX XX	00 00 00 00	00 XX XX XX
	0	00 00 00 00	00 XX XX XX	00 10 00 00	00 XX XX XX
	+127	00 01 11 11	11 XX XX XX	00 11 11 11	11 XX XX XX
90°	-128	01 10 00 00	00 XX XX XX	01 00 00 00	00 XX XX XX
	0	01 00 00 00	00 XX XX XX	01 10 00 00	00 XX XX XX
	+127	01 01 11 11	11 XX XX XX	01 11 11 11	11 XX XX XX
180°	-128	10 10 00 00	00 XX XX XX	10 00 00 00	00 XX XX XX
	0	10 00 00 00	00 XX XX XX	10 00 00 00	00 XX XX XX
	+127	10 01 11 11	11 XX XX XX	10 11 11 11	11 XX XX XX
270°	-128	11 10 00 00	00 XX XX XX	11 00 00 00	00 XX XX XX
	0	11 00 00 00	00 XX XX XX	11 10 00 00	00 XX XX XX
	+127	11 01 11 11	11 XX XX XX	11 11 11 11	11 XX XX XX

Auto Function Control commands:

	Command	Val	Request	Val	Response	Val
Start Code	STX	0x02	-	-	STX	0x02
n	2	0x02	-	-	3	0x03
(DT1)	Control	0x40	-	-	Control	0x40
(DT2)	Mode	0x00 – 0xFF see table	-	-	Mode	0x00 – 0xFF see table
(DT3)	-	-	-	-	Result	0x00 – 0xFF see table

Table 77; Auto Function Control Commands

Item	(DT1) DTL	(DT2) MODE	(DT3) RESULT
AUTO WHITE	0x40	0x10	0x01:"OK"COLOR TEMPERATURE 3200K 0x02:"OK"COLOR TEMPERATURE 5600K 0x11:"NG","CHANGE TO CAM" 0x12:"NG","CHANGE TO MEM" 0x13:"NG","LOW LIGHT" 0x15:"NG","C.TEMP.HI" 0x16:"NG","C.TEMP.LOW" 0x18:"NG","???"
AUTO BLACK		0x20	0x00:"OK" 0x11:"NG","CHANGE TO CAM" 0x17:"NG","IRIS NOT CLOSE" 0x18:"NG","???"
AUTO SHADING		0x30	0x00:"OK" 0x11:"NG","CHANGE TO CAM" 0x13:"NG","LOW LIGHT" 0x15:"NG","C.TEMP.HI" 0x16:"NG","C.TEMP.LOW" 0x18:"NG","???" 0x19:"NG","CONTROL LIMIT"
AUTO SHADING (LUMI MODE)		0x31	0x00:"OK" 0x11:"NG","CHANGE TO CAM" 0x13:"NG","LOW LIGHT" 0x15:"NG","C.TEMP.HI" 0x16:"NG","C.TEMP.LOW" 0x18:"NG","???" 0x19:"NG","CONTROL LIMIT"
AUTO SHADING (COLOR MODE)		0x32	0x00:"OK" 0x11:"NG","CHANGE TO CAM" 0x13:"NG","LOW LIGHT" 0x15:"NG","C.TEMP.HI" 0x16:"NG","C.TEMP.LOW" 0x18:"NG","???" 0x19:"NG","CONTROL LIMIT"

Character String Display Control commands:

	Command	Val
Start Code	STX	0x02
n	2	0x02
(DT1)	Control	0x48
(DT2)	Mode	0x00
(DT3-DT14)	String	see table
(DT15)	End Character	0x00

Table 78:Character String Display Control Commands

Item	(DT1) CTL	(DT2) MODE	(DT3),(DT4) (DT15) DATA
TITLE DATA SET	0x48	0x00	CHR$(code)+CHR$(code)+ +0x00 12 characters (See below)

CHR.	ASCII code	CHR	ASCII code	CHR.	ASCII code	CHR.	ASCII code
SPACE	0x20	<	0x3C	Q	0x51	j	0x6A
*	0x2A	>	0x3E	R	0x52	k	0x6B
+	0x2B	?	0x3F	S	0x53	l	0x6C
,	0x2C	A	0x41	T	0x54	m	0x6D
-	0x2D	B	0x42	U	0x55	n	0x6E
.	0x2E	C	0x43	V	0x56	o	0x6F
/	0x2F	D	0x44	W	0x57	p	0x70
0	0x30	E	0x45	X	0x58	q	0x71
1	0x31	F	0x46	Y	0x59	r	0x72
2	0x32	G	0x47	Z	0x5A	s	0x73
3	0x33	H	0x48	a	0x61	t	0x74
4	0x34	I	0x49	b	0x62	u	0x75
5	0x35	J	0x4A	c	0x63	v	0x76
6	0x36	K	0x4B	d	0x64	w	0x77
7	0x37	L	0x4C	e	0x65	x	0x78
8	0x38	M	0x4D	f	0x66	y	0x79
9	0x39	N	0x4E	g	0x67	z	0x7A
:	0x3A	O	0x4F	h	0x68		
;	0x3B	P	0x50	i	0x69		

Note that the Title Data Set command is used internally by the VCU to automatically display the time on the camera output. The Title Data Set command does not disable the automatic time overlay function if this function is active.

CAM Overlay Time Parameters

The Overlay Time command provides a way to enable or disable the automatic overlay of the system time. This is implemented in S/W.

CAM Overlay Time Parameters			
Offset	Description	Value	Remarks
0	Camera selection	0: CAM 1 1: CAM 2 2: CAM 3 3: CAM 4	
1	Enable	0: Off 1: On	

Table 79: CAM Overlay Time Parameters

Appendix D: Error and Severity Codes

Severity codes

In the following table the severity codes are listed which can be used in the *Severity* field of the log messages shown in Table 48(page 61) and the sections referring to the individual interfaces listed above. Note that there is no direct relation between the severity field in the log messages and the C&W words in the housekeeping data.

Severity Code	description	Clarification
0x00	Info	records the progress of normal operation
0x01	Warning	records when an undesirable situation or forthcoming alarm is detected
0x02	Alarm	records when a serious situation, possibly requiring a ground response, is detected
0x03	Error	records when a hardware or an internal software error is detected

Table 80: Log Message severity codes

Error Codes

In the following table the error codes are listed which can be sent by:

- ECB
- SB
- ASW
- Video

These error codes can be used in the log message Error Code field as shown in Table 48 (page 61) and the sections referring to the individual interfaces listed above. An error code should always be viewed in combination with its source to determine cause and impact.
Note that the error codes send by any of the other interfaces are not listed in the table; these are interface/experiment specific and therefore outside the scope of this document.
Other error codes could be sent by the sources indicated, in which case the accompanying text should be self-explanatory.

Error Code	Error description	Explanation
0x01	Invalid Command	Command received is not in range (not valid) or command destination not correct
0x02	Invalid Parameter	Command Parameter out of range (not valid)
0x03	Checksum Error	Command received, failed the checksum test (error in transmission)
0x04	Internal Error	Software detects an internal error

Table 81: Log Message Error codes

Appendix E: Commands List

This appendix contains a complete listing of all commands, which can be sent to the RC, either from the ISS/ground or MLC. In Table 82 the general format of a MSG command message to one of the components is described. It does not include the additional CCSDS header which is mandatory for all communication on the external MIL-bus (Source = ma_ISS_XBUS, [AD5]), but does include the Sequence counter field only present in messages from the MLC (Source=ma_MLC).

Title : general command format Direction: ISS/MLC->RC Protocol: MIL 1553B Frequency: Asynchronous					
Offset (bytes)		Field Name	#bytes	Value	Remarks
ISS	MLC				
NA	0	Sequence Counter	2		Field only present when Source=ma_MLC
0	2	Source	1	ma_ISS_XBUS or ma_MLC	Two possible sources of commands
1	3	Destination	1	ma_ECB, ma_MLC, ma_RPDA, ma_SB, ma_VIDEO, ma_WV1 **or** ma_WV2	Intended final destination of the command, see Appendix B: Constant Assignments
2	4	Class	1	See §3.1.2, page 17	default: mc_CMD_AND_ACK + sequence counter
3	5	Type	1	CMD ID	depending on destination
4	6	Length	2	parameter length	Number of bytes following this field **Note:** this field is not present when the Destination is ma_SSL!
6	8	Parameters			Optional parameters (command specific)

Table 82: General command format for external commands to RC.

The maximum length of a command as displayed in the table above can be 53 words, excluding the sequence counter [AD5].
All available commands are displayed in the following table and are grouped by destination. Numeric values of CMD ID fields are listed in Appendix B.

CMD ID	Comment
↓ Destination: **ma_ASW**, see §3.1.12.2.5, page 53 for parameters & details	
cmd_FILE_UPLOAD	Upload file command
cmd_SW_FILE_FLASH_STORE	Command to store the software file on SPLC flash PROM
cmd_ASW_ADD_ROUTE	add a data route
cmd_ASW_DELETE_ROUTE	delete a route
cmd_ROUTE_REPORT	generate report of all existing data routes
cmd_RAM_DRIVE_INIT	initialize/install a RAM drive
cmd_RAM_DRIVE_REMOVE	removes a RAM drive created with cmd_RAM_DRIVE_INIT
cmd_OPEN_LRT_CHANNEL	open an LRT channel on the MIL-bus to the station MDM
cmd_CLOSE_LRT_CHANNEL	close LRT channel opened with cmd_OPEN_LRT_CHANNEL
cmd_STORE_USER_LIM_SET	Store the current Limit settings
cmd_REMOVE_USER_LIM_SET	Remove the settings stored with cmd_STORE_USER_LIM_SET
↓ Destination: **ma_ECB**, see §3.1.7.2, page 25 for parameters & details	
cmd_ENABLE_ECB_DATA	Start sending LRT
cmd_DISABLE_ECB_DATA	stop sending LRT
cmd_OUTPUT_BYTE	bitmask to turn on/off the 8 digital outputs
cmd_SELECT_CHAN	configure what LRT to sent
↓ Destination: **ma_SB**, see §3.1.9.4, page 31 for parameters & details	
cmd_AL_ILLUMINATION	Airlock Illumination on/off
cmd_FAN_SP_SPEED_NORMAL	Setpoint Fan Speed Normal Mode
cmd_FAN_SP_SPEED_DONNING	Setpoint Fan Speed Donning Mode
cmd_PCV_DONNING	Donning on/off
cmd_PCV_SP_NEG_PRESS	Setpoint Negative Pressure WV
cmd_WV_ILLUMINATION	WV Illumination on/off
cmd_WV_ILL_SP_INTENSITY	Setpoint WV Illumination Intensity
cmd_EXP_1_PWR_0	Experiment outlet 1 +5V on/off
cmd_EXP_1_PWR_1	Experiment outlet 1 ±12V on/off
cmd_EXP_1_PWR_2	Experiment outlet 1 +28V on/off
cmd_EXP_2_PWR_0	Experiment outlet 2 +5V on/off
cmd_EXP_2_PWR_1	Experiment outlet 2 ±12V on/off
cmd_EXP_2_PWR_2	Experiment outlet 2 +28V on/off
cmd_EXP_PWR_120	Experiment +120V on/off
cmd_EXP_PWR_ICP	ICP + 12V on/off
↓ Destination: **ma_MLC**, see §3.1.11.4.3, page 47 for details	
0x00 .. 0xFF	Experiment specific; either commands to the MLC itself or intended to be rerouted through/by the MLC
↓ Destination: **ma_RPDA**, see §3.1.10.3, page 39 for parameters & details	
cmd_ESEM3_O1_FAN_MOTORS	Fan Motors
cmd_ESEM3_O2_EXP_POWER_120V	Exp.Power (120V)
cmd_ESEM4A_O1_LAPTOP	laptop connector (28V)
cmd_AAA_SPEED	AAA speed
cmd_ESEM3_O3_CMP_AND_ EXP_12V_5V	CMP and VCU power
cmd_ESEM3_O4_AAA_AND_ASDA	power to AAA and smoke detector
cmd_ESEM4B_O1_ILLUM_SPLC_AIR LOCK	WV illumination, airlock and SPLC
cmd_ESEM4B_O2_EXP_POWER_28V	Exp. power (28V)
cmd_ESEM4A O2_VIDEO	video system
cmd_ESEM1_DIG_TEST_IN	Digital ESEM I/F test
cmd_ESEM3_DIG_TEST_IN	Digital ESEM I/F test
cmd_ESEM4A_DIG_TEST_IN	Digital ESEM I/F test
cmd_ESEM4B_DIG_TEST_IN	Digital ESEM I/F test
↓ Destination: **ma_VIDEO**, see §3.1.8.1, page 28 / Appendix C for details & parameters	
cmd_SYSTEM_TIME	Sets system time for the Video Assembly.

CMD ID	Comment
cmd_POWER_CONTROL	Switches power on/off
cmd_VIDEO_ROUTING	Selects input source for monitors and downlink
cmd_VCR_STOP	Sends Stop command to recorder (release tape)
cmd_VCR_PAUSE	Sends Pause command to recorder (hold tape)
cmd_VCR_PLAY	Sends Start command to recorder
cmd_VCR_RECORD	Sends Record command to recorder (continuous recording)
cmd_VCR_TIMELAPSE	Starts timelapse recording.
cmd_VCR_FFWD	Sends Forward command to recorder
cmd_VCR_REW	Sends Rewind command to recorder
cmd_CAM_TIME_OVERLAY	Enable/Disables automatic overlay of time
cmd_CAM_DIRECT	Provides a direct command interface to the camera.
↓ Destination: **ma_WV1** or **ma_WV2**, see §3.1.5.3, page 21 for details	
0x00 .. 0xFF	Experiment specific; out of the scope of this document
↓ Destination: **ma_SSL**, see §3.1.12.2.6, page 55 for a summary, but App. B of [AD8] for details	
SSL_CMD_FILE_USL_FT_ uploadStart	Initiate an upload of a file to the US-Lab DMS
SSL_CMD_FILE_USL_FT_ downloadStart	Initiate a download of a file from the US-Lab DMS
SSL_CMD_MON_setLimitsBOOL	Set the limits of a monitored parameter of type BOOL
SSL_CMD_MON_setLimitsUINT	Set the limits of a monitored parameter of type UINT
SSL_CMD_MON_setLimitsINT	Set the limits of a monitored parameter of type INT
SSL_CMD_MON_setLimitsFLOAT	Set the limits of a monitored parameter of type FLOAT
SSL_CMD_MON_getAttribs	Retrieve the attributes of a monitored parameter.
SSL_CMD_MON_enablePar	Enable/disable the monitoring of a parameter
SSL_CMD_MON_setViolations	Set the number of violations until a monitor action is performed
SSL_CMD_TASK_reboot	Reboot the SPLC

Table 83: Listing of MSG commands